USGS National Seismic Hazard Mapping Project:

Ground Motion Prediction Equations

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USGS Menlo Park

Dec. 12/13, 2012

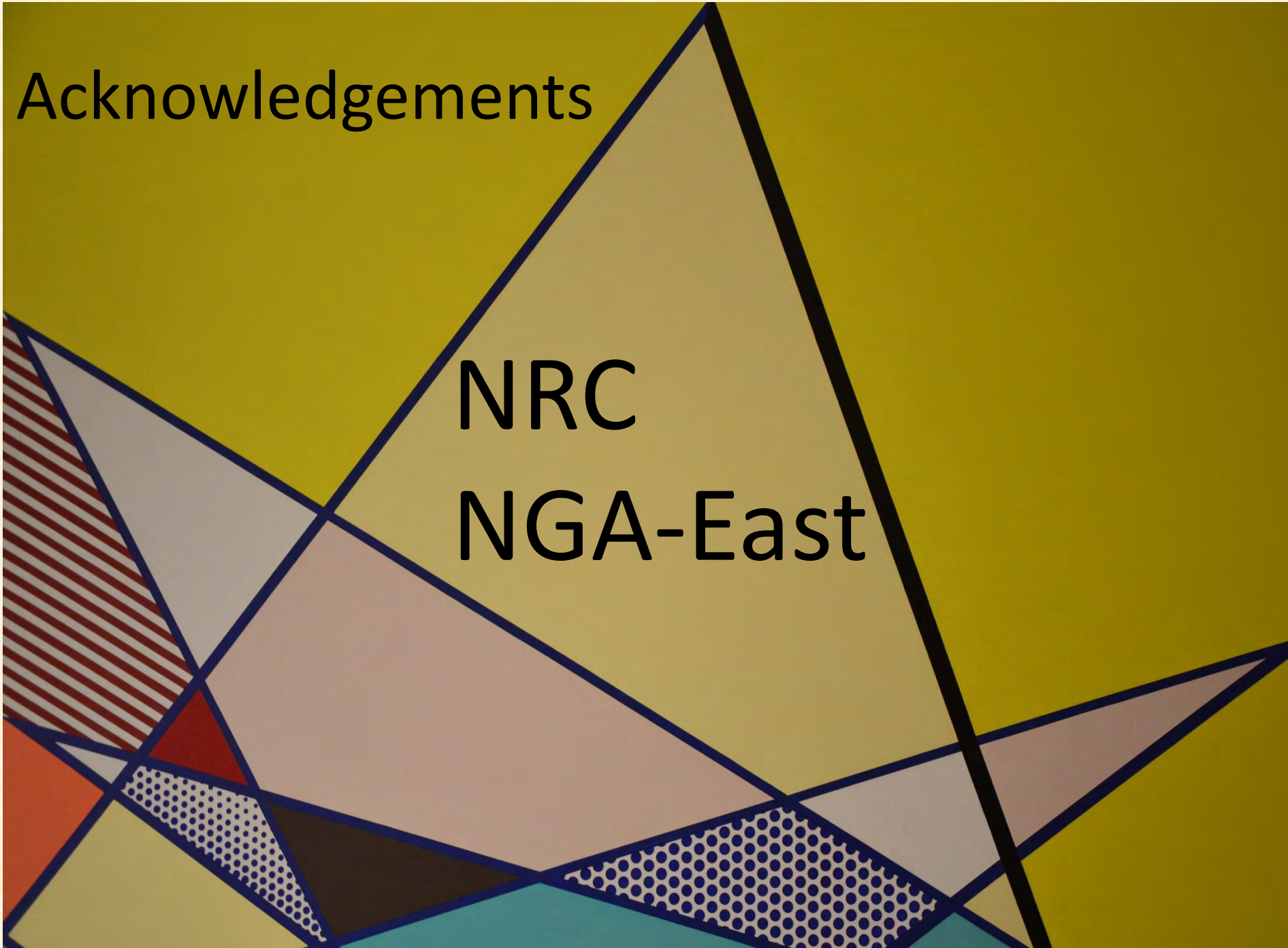
Hosted by PEER
Berkeley, CA

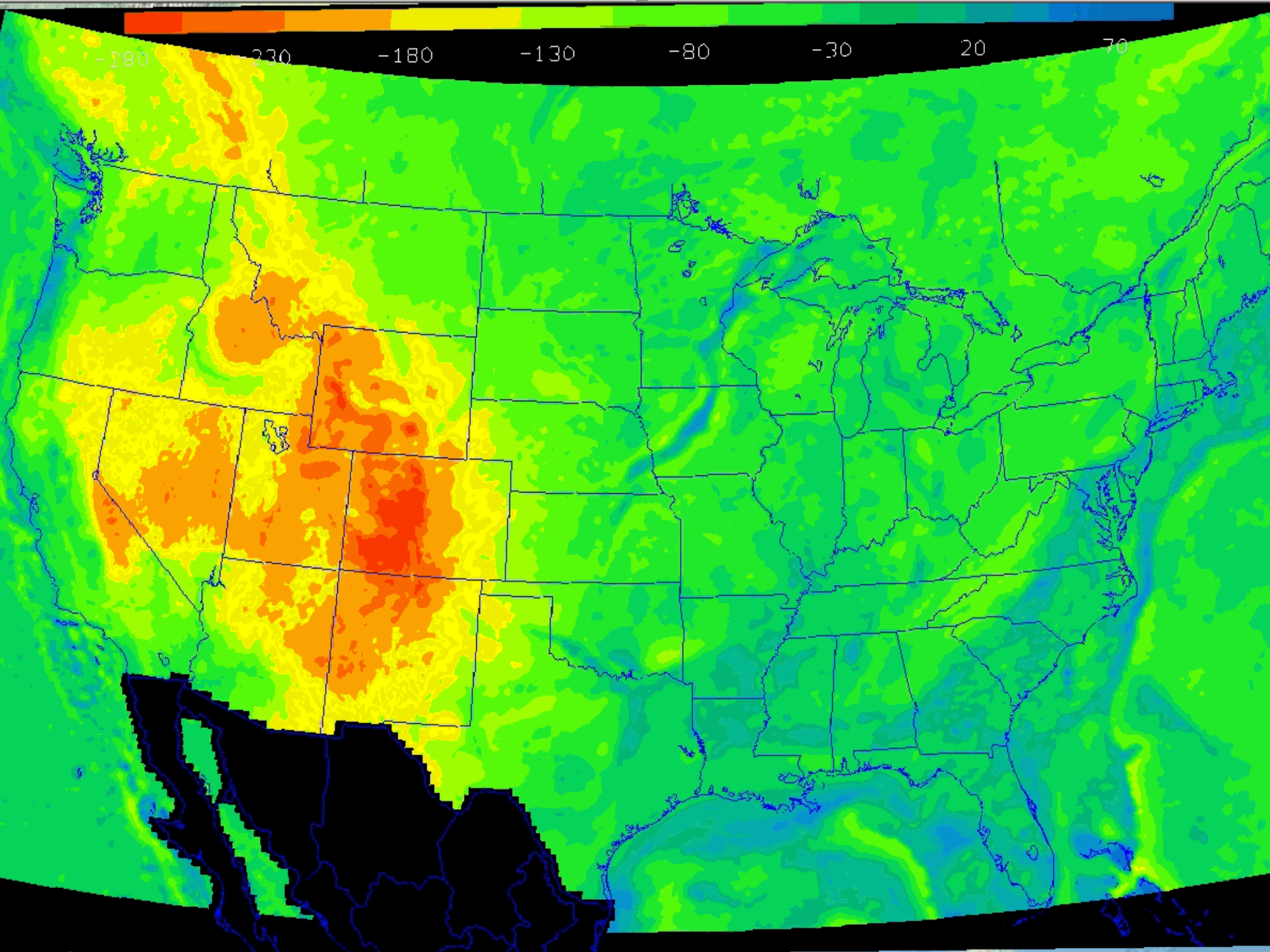
We are expanding on two previous reports:

1. GSA Memoir 172, 1989, “Geophysics of the Conterminous US”, Pakiser and Mooney.

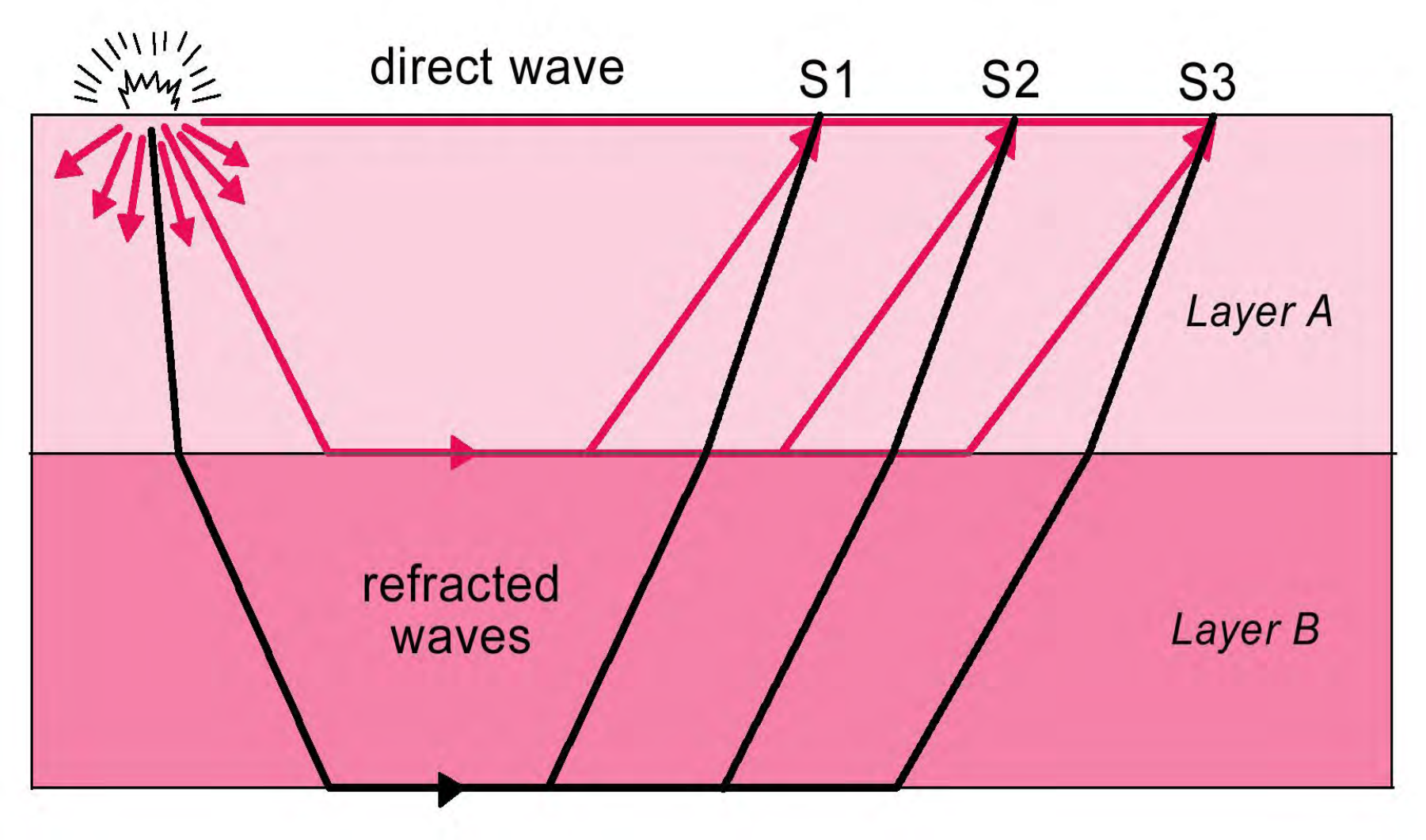
2. Chulick and Mooney, 2002, Crustal Structure of North America, BSSA.

Acknowledgements

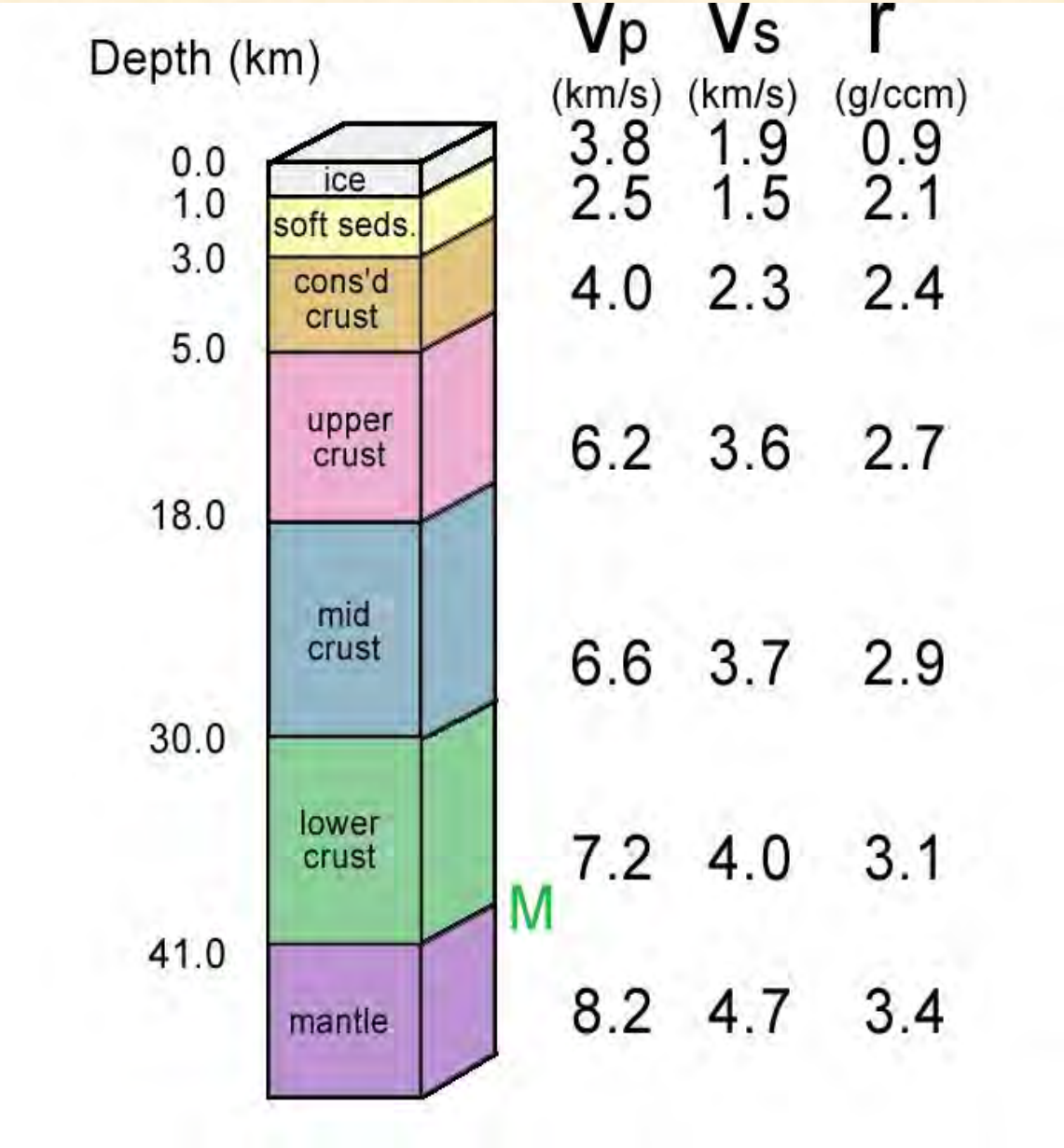


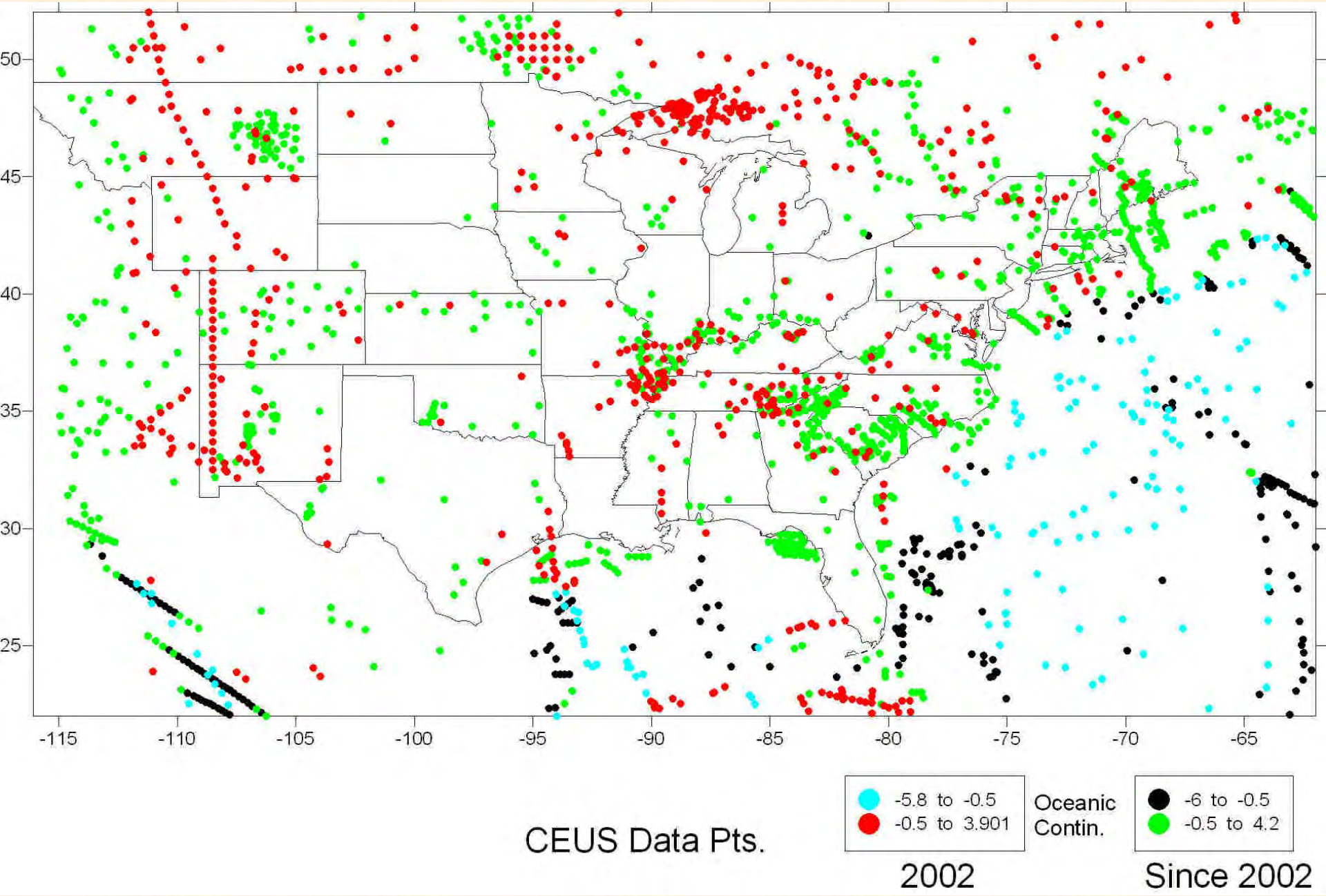

-280
-230
-180
-130
-80
-30
20
70

Measuring Crustal Velocities and Thickness



Typical Stable Continental Crust: Platform

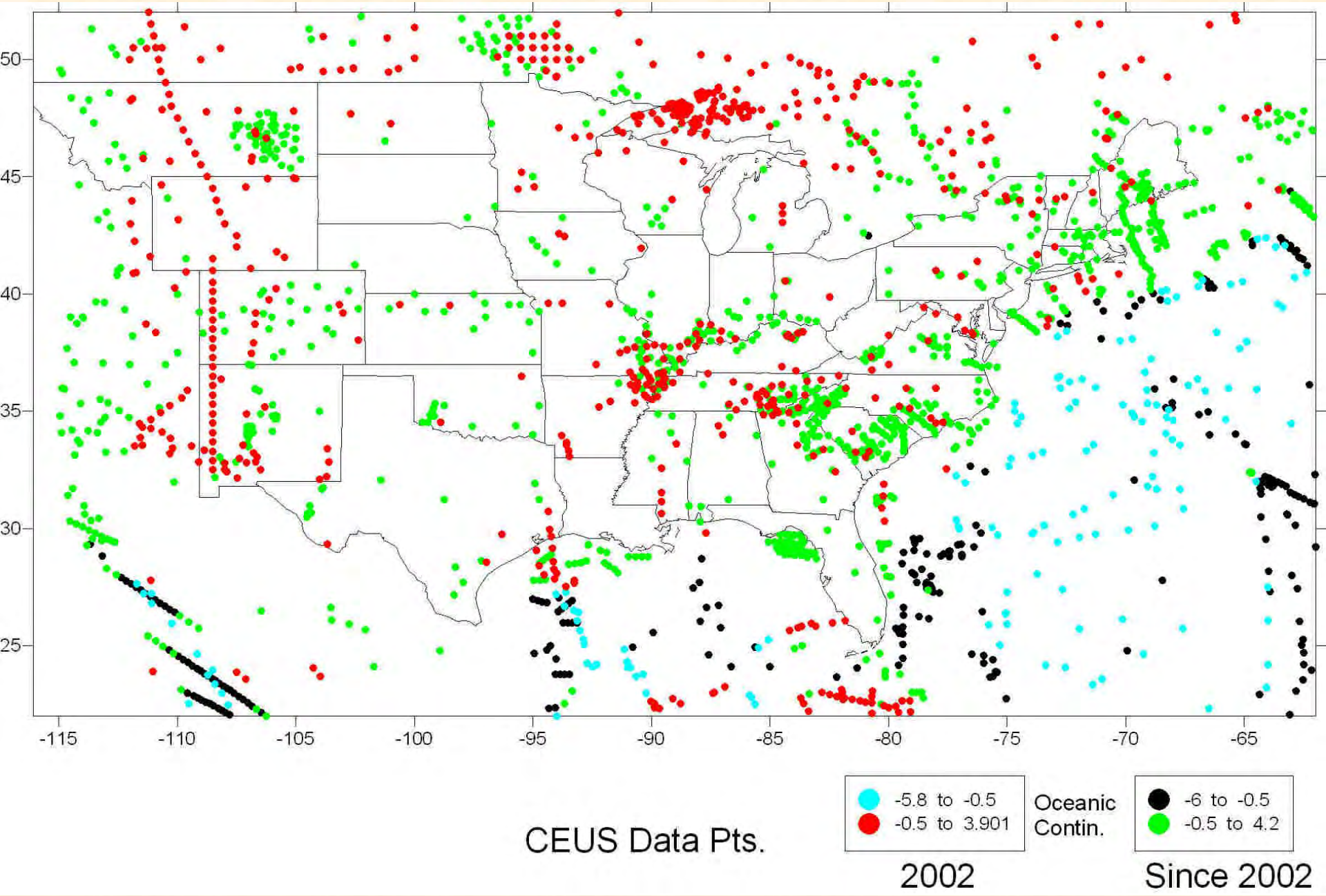



50
45
40
35
30
25
-115
-110
-105
-100
-95
-90
-85
-80
-75
-70
-65
-5.8 to -0.5
-0.5 to 3.901
Oceanic
Contin.
-6 to -0.5
-0.5 to 4.2
CEUS Data Pts.
2002
Since 2002

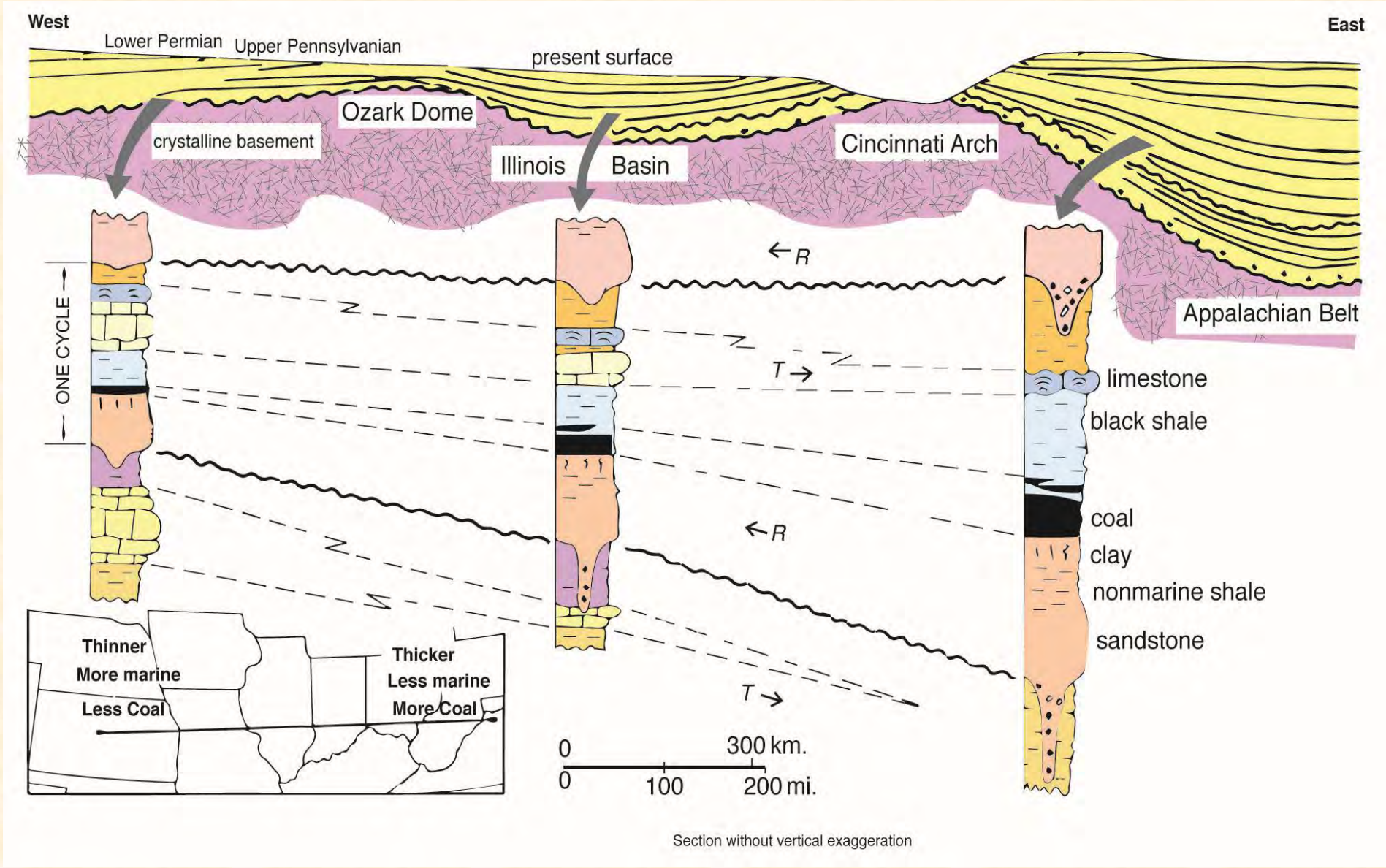

THE WORLD

CEUS Velocity vs. Depth

Profiles	2002 (Chulick & Mooney, BSSA)	October 2012
P-wave	792	2240
S-wave	100	464
Total	818	2384
Moho Depth	604	1419


50
45
40
35
30
25
-115
-110
-105
-100
-95
-90
-85
-80
-75
-70
-65
-5.8 to -0.5
-0.5 to 3.901
Oceanic
Contin.
-6 to -0.5
-0.5 to 4.2
CEUS Data Pts.
2002
Since 2002

Paleozoic Cover Rock



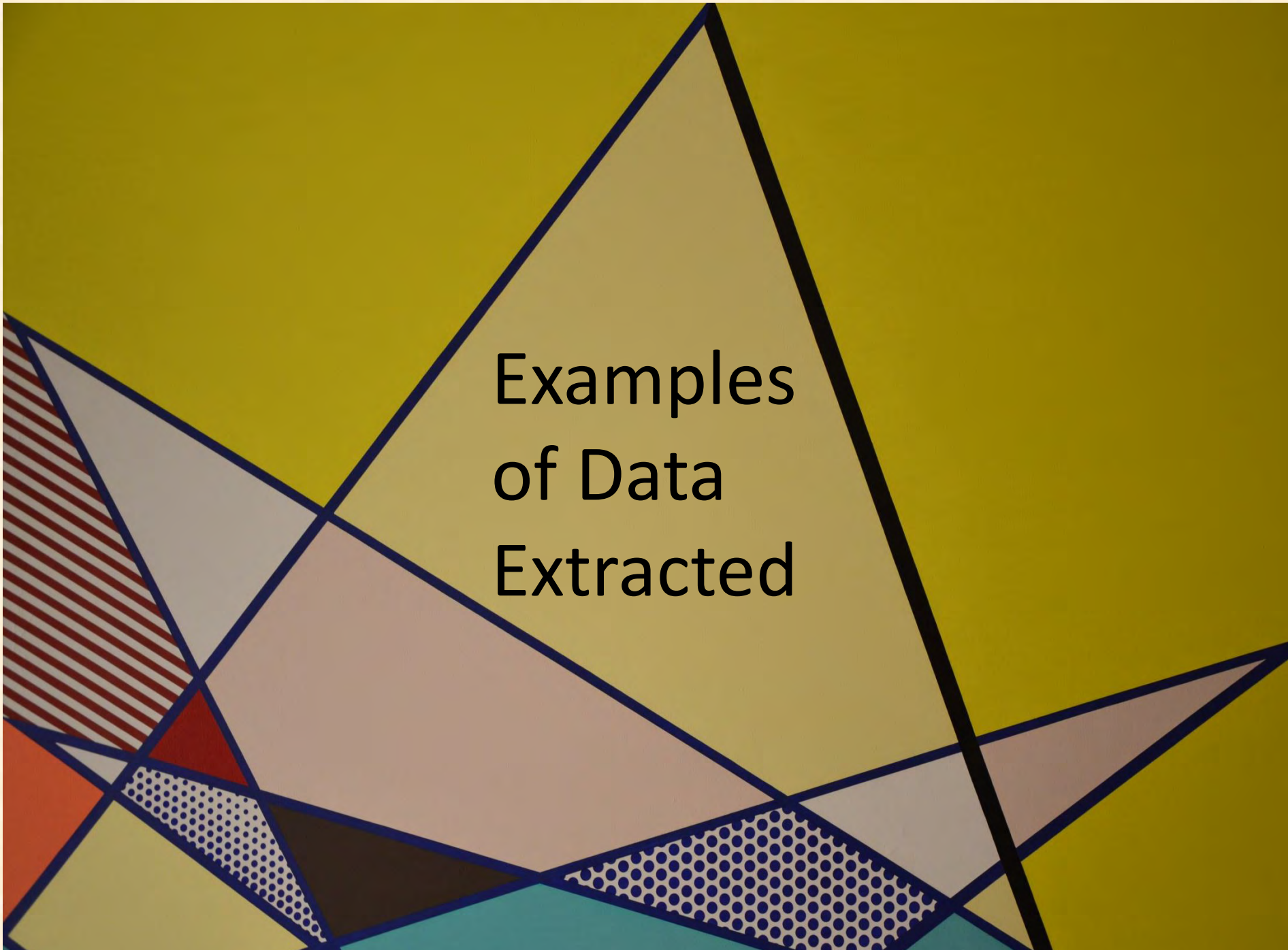
Data Records Include:

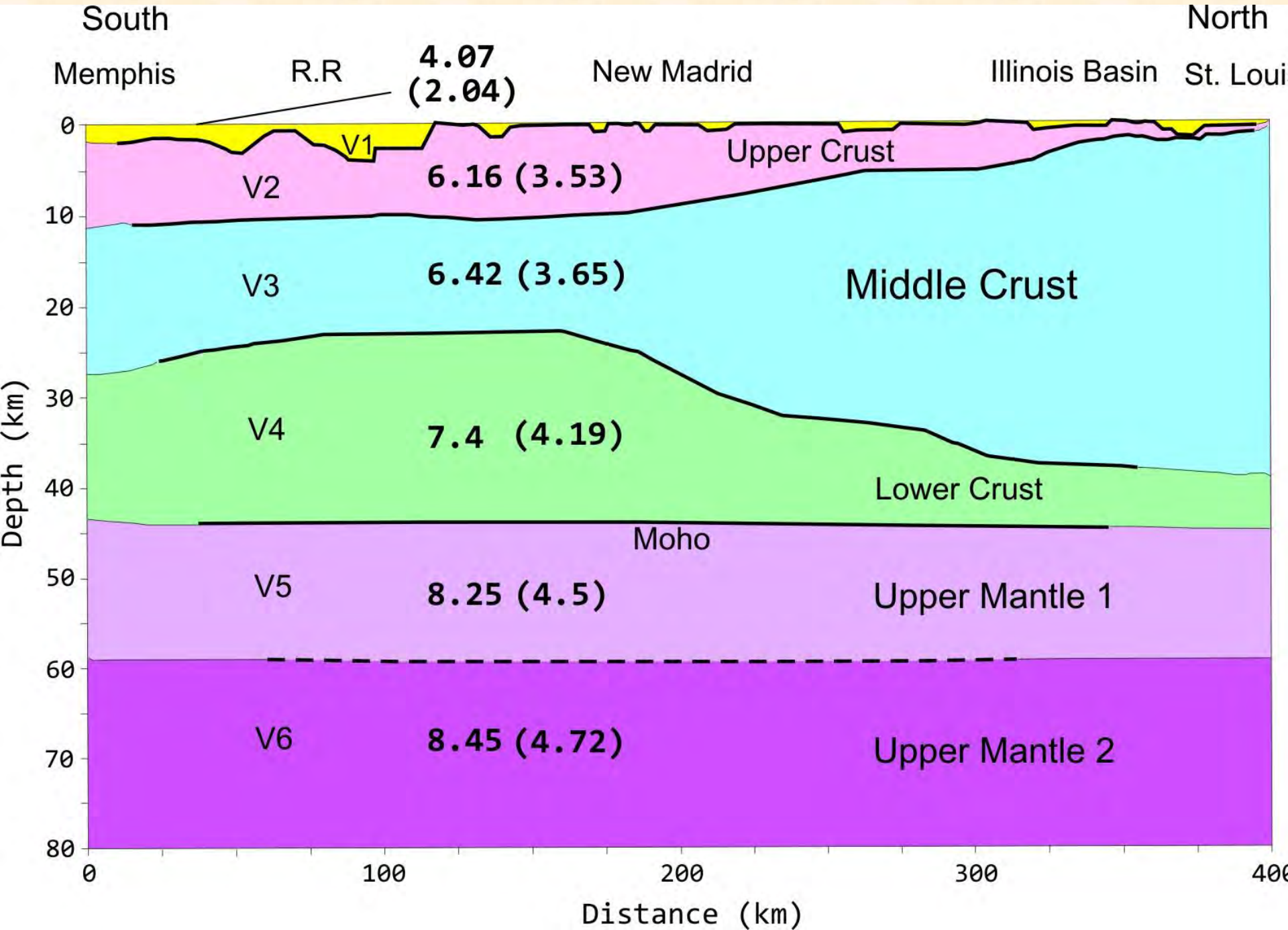
1) Latitude & Longitude of measurement point
2) Structure of entire crust:
   - P-wave velocity
   - S-wave velocity (where available)
   - sediment thickness
   - thickness of crystalline crust
   - detailed description of crustal layering
3) Crustal Type (such as basins, shields, orogens, etc)
4) Tectonic Age
5) Experimental details

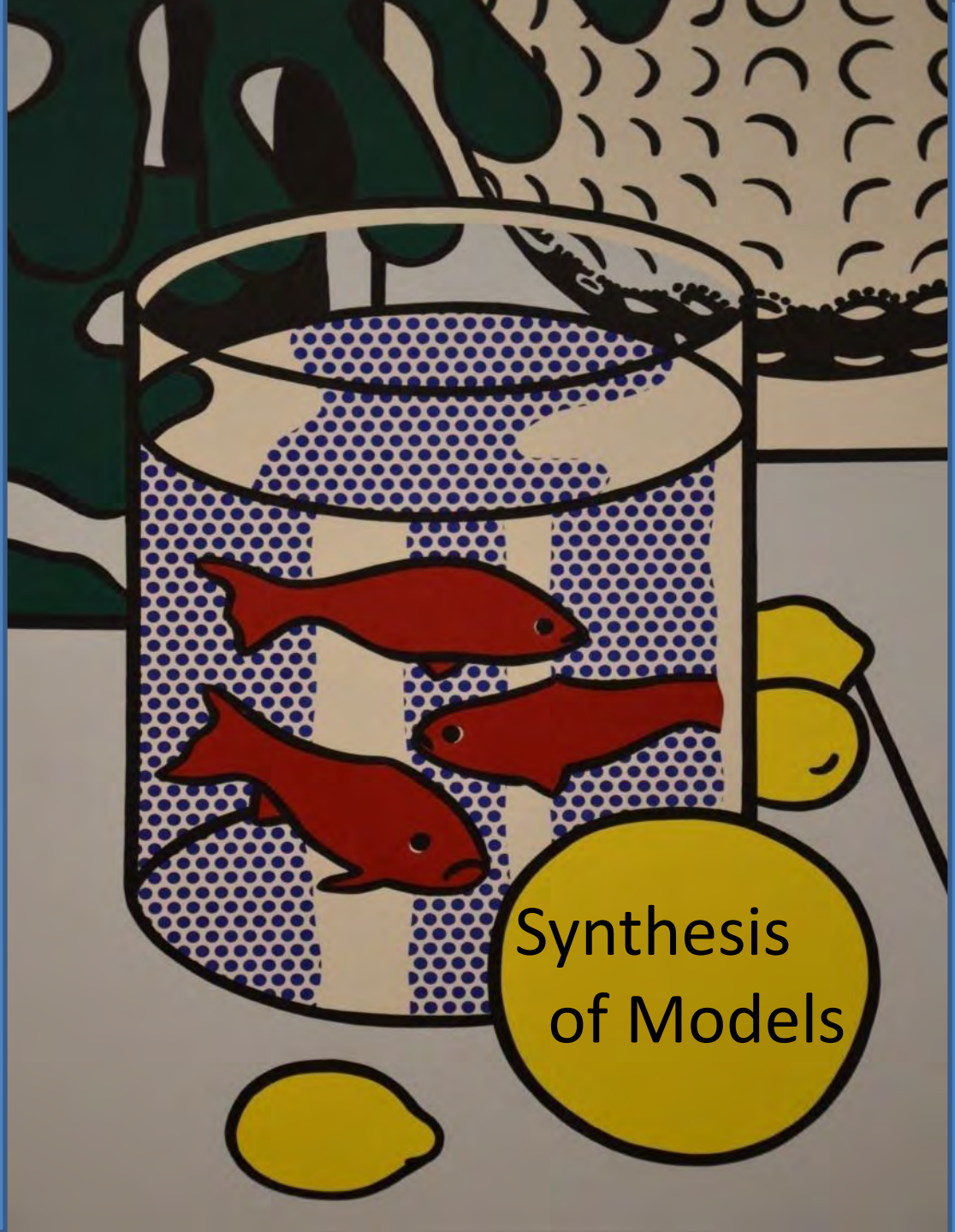
Sample Data Record:

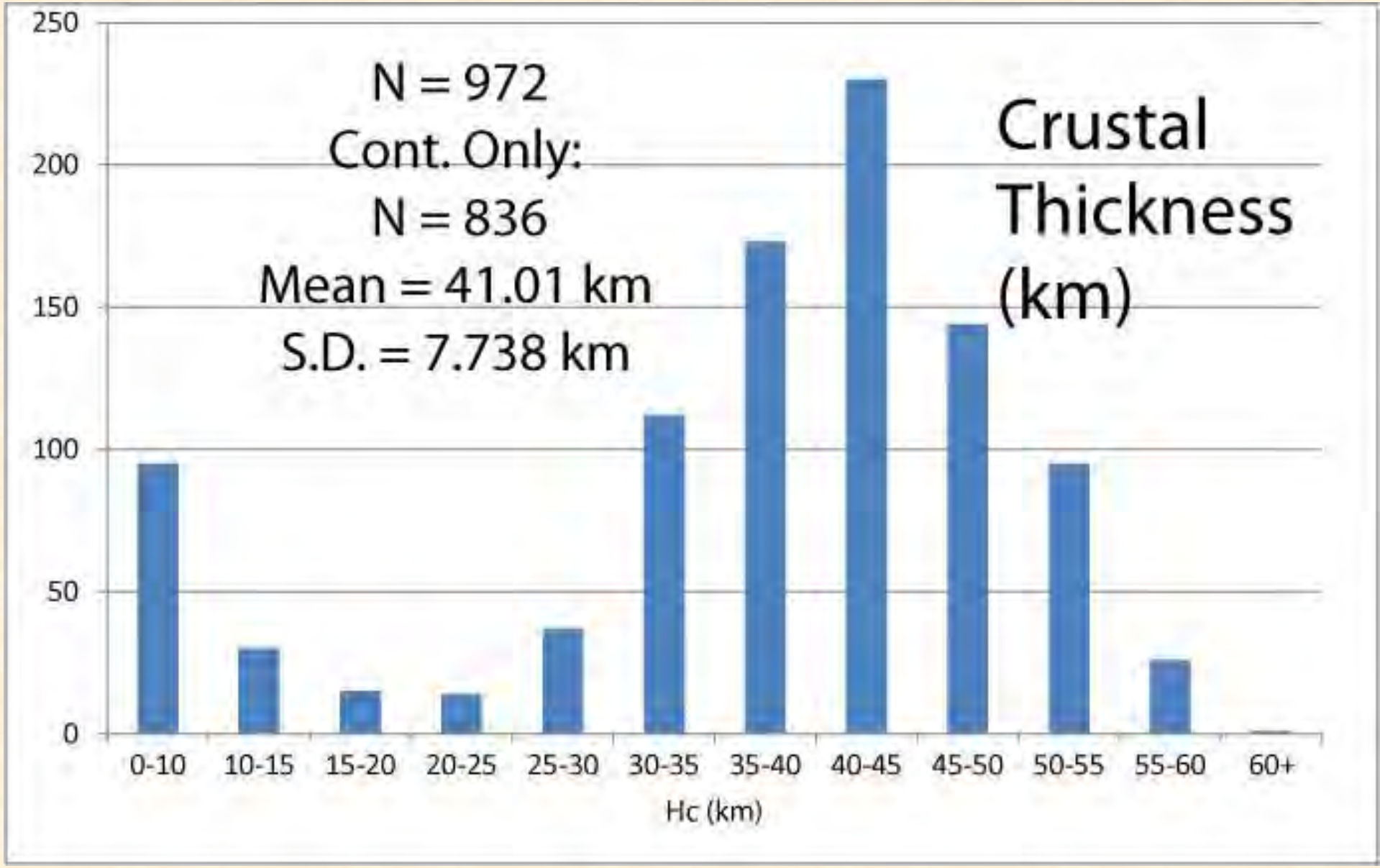
mn	lat	vp	vs	t	d	nt	hcc	h	hf	gl	Com
	lon						hc	age	az	ref	gp
289	68.36N	3.10	1.44	1.30	.00	s	24.60	-0.30	.00	EUC-CS	6 R
	11.90E	5.10	3.19	.50	1.30	s	26.40	MCz	51.10	92M.1	EXC
		6.00	3.43	4.20	1.80	c					
		6.40	3.66	11.60	6.00	c					
		6.80	3.74	8.80	17.60	c					
		8.20	5.12	.00	26.40	m					

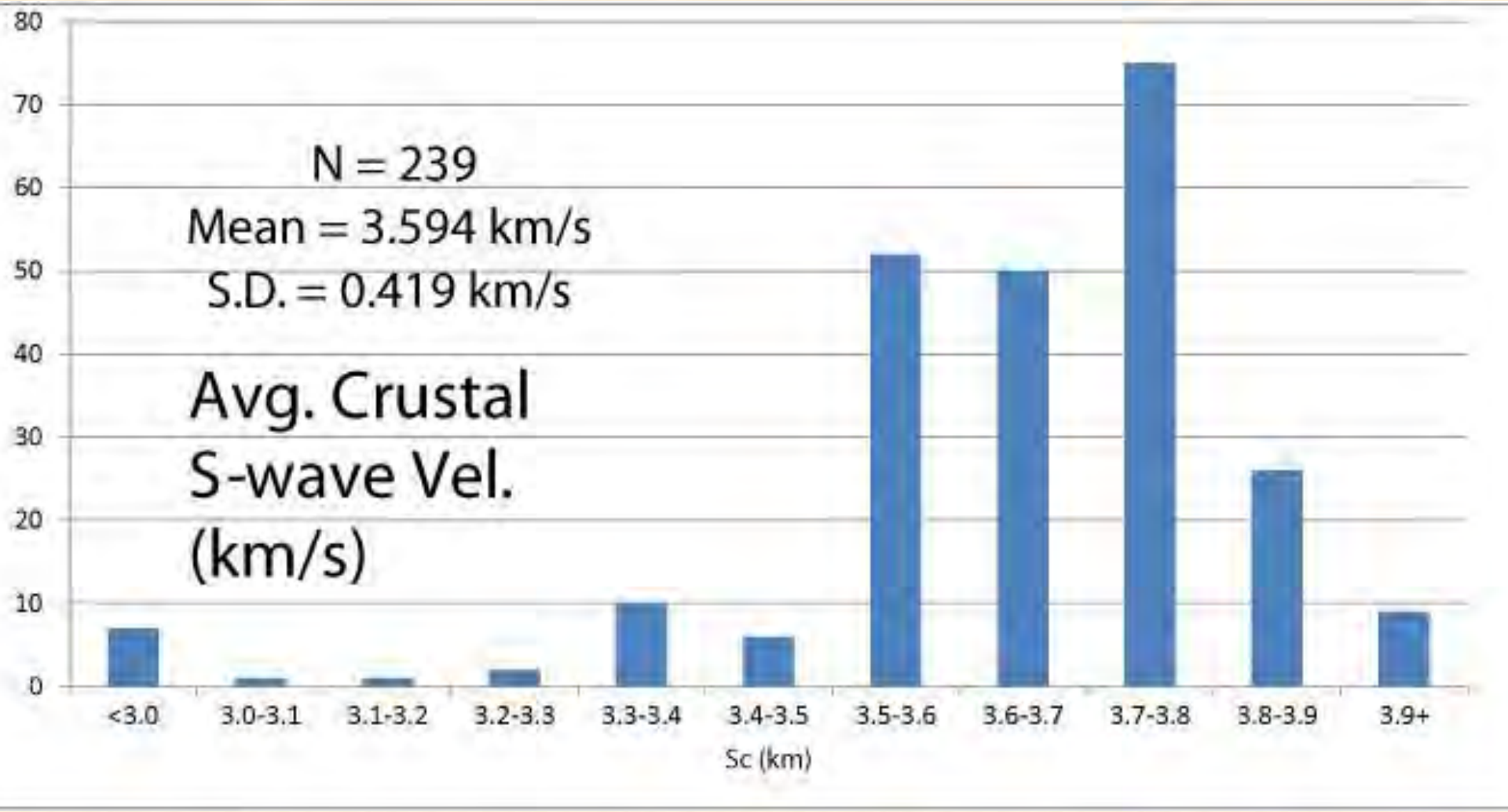
mn	record number
lat	location in degrees latitude
lon	location in degrees longitude
vp	p(compressional) wave velocity in km/s
vs	s(shear) wave velcity in km/s
t	layer thickness in km
d	depth to top of layer in km
nt	notes on layer type
	s sedimentary/volcanic (lava flows)
	c crystalline (basement)
	m mantle
hcc	total thickness of crystalline (non-sed) crust in km
hc	total crustal thickness in km
h	altitude in km (negative represents water depth)
gl	geographical location of profile
Com	comments list # of layers and profile type
hf	heatflow
age	age of last thermo-tectonic event
az	azimuth of shot profile line with respect to North Pole
ref	reference code
gp	geological province


Examples
of Data
Extracted


South
North
Memphis
R.R
4.07
(2.04)
New Madrid
Illinois Basin
St. Loui
V1
V2
6.16 (3.53)
Upper Crust
V3
6.42 (3.65)
Middle Crust
V4
7.4 (4.19)
Lower Crust
Moho
V5
8.25 (4.5)
Upper Mantle 1
V6
8.45 (4.72)
Upper Mantle 2
Depth (km)
0
10
20
30
40
50
60
70
80
0
100
200
300
400
Distance (km)

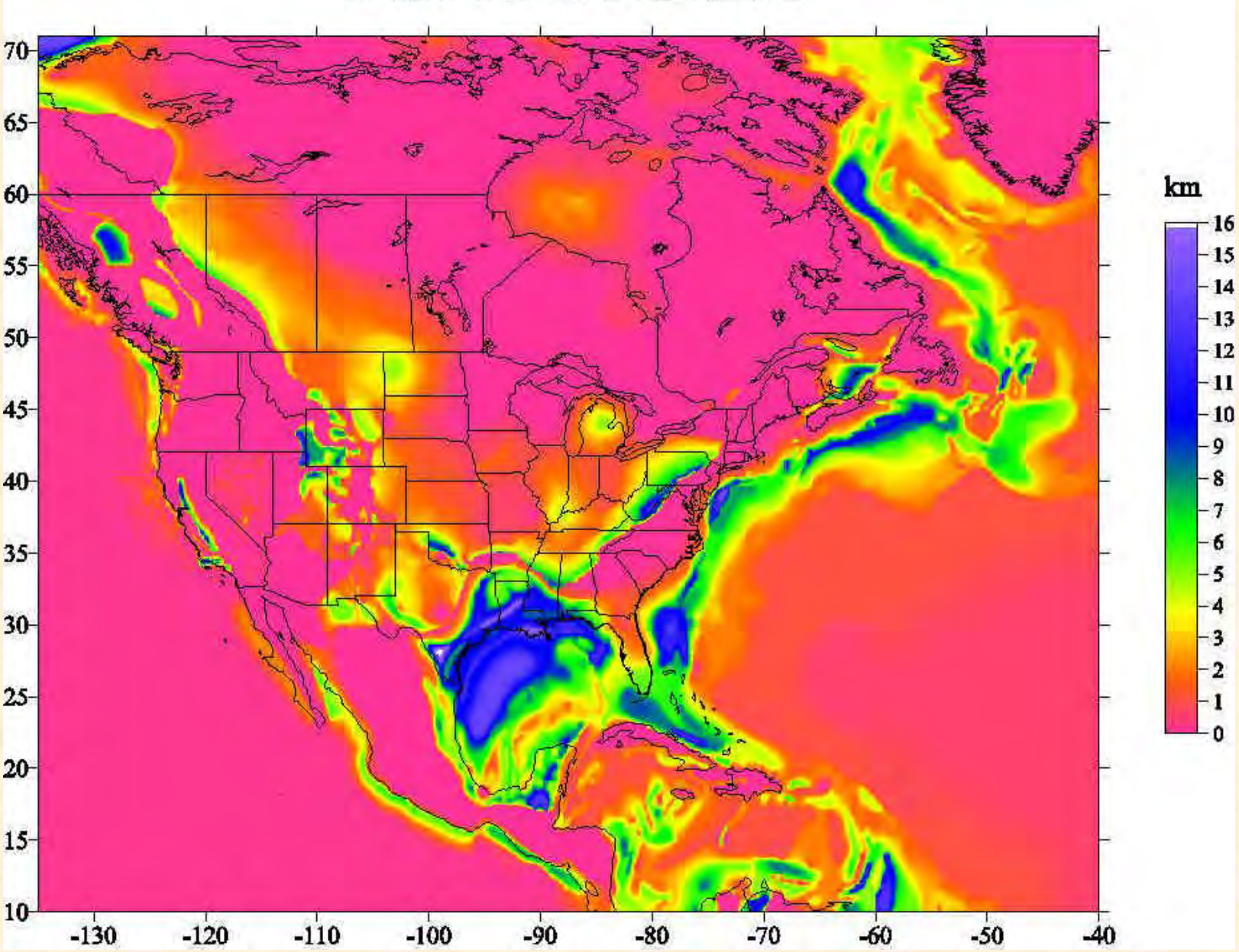

Synthesis
of Models

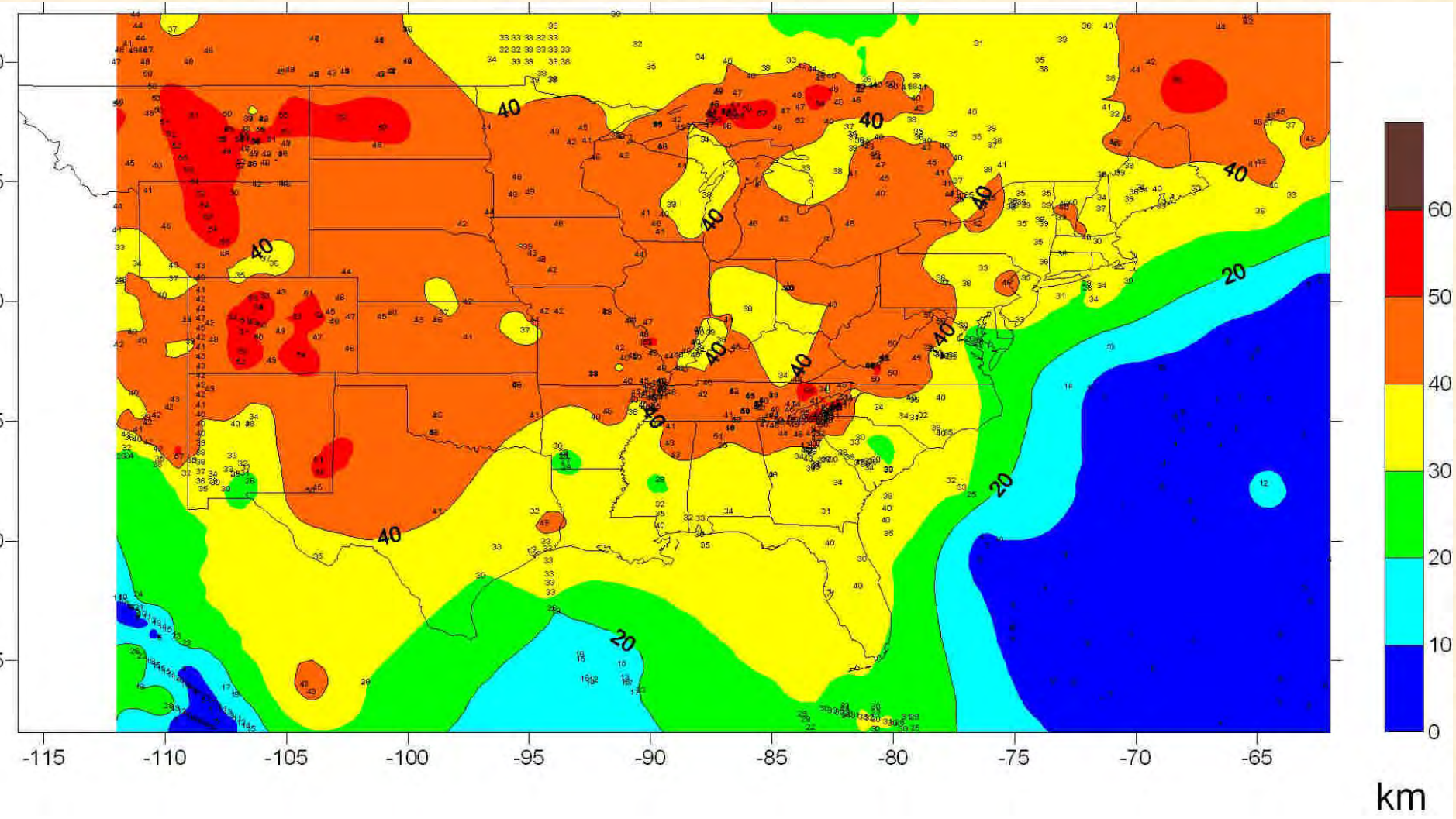

N = 972
Cont. Only:
N = 836
Mean = 41.01 km
S.D. = 7.738 km
Crustal Thickness (km)
250
200
150
100
50
0
0-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
50-55
55-60
60+
Hc (km)


N = 239
Mean = 3.594 km/s
S.D. = 0.419 km/s
Avg. Crustal
S-wave Vel.
(km/s)
80
70
60
50
40
30
20
10
0
<3.0
3.0-3.1
3.1-3.2
3.2-3.3
3.3-3.4
3.4-3.5
3.5-3.6
3.6-3.7
3.7-3.8
3.8-3.9
3.9+
Sc (km)

Contour Maps

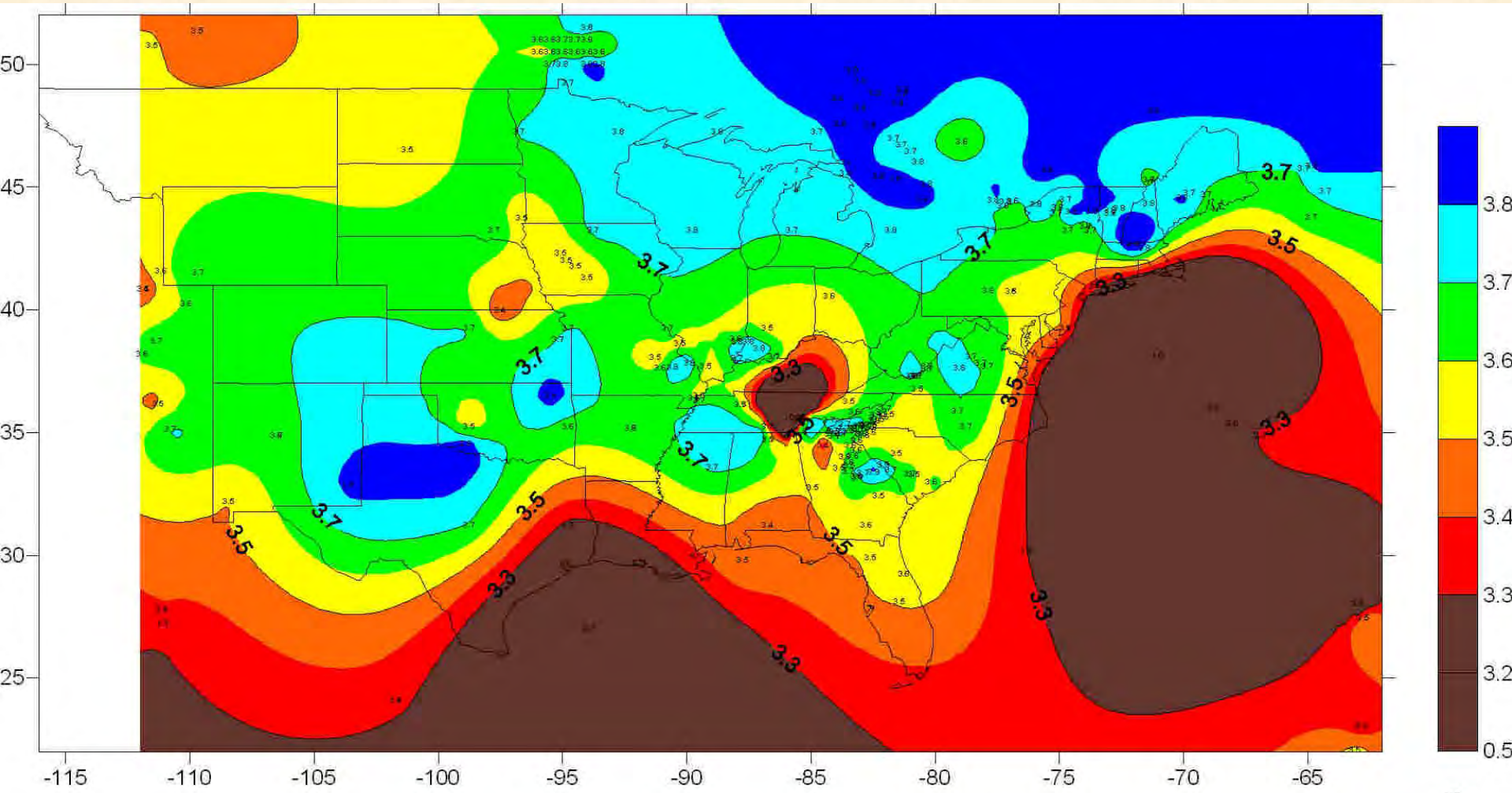
Thickness of Sediments, Mooney and Kaban, JGR, 2010





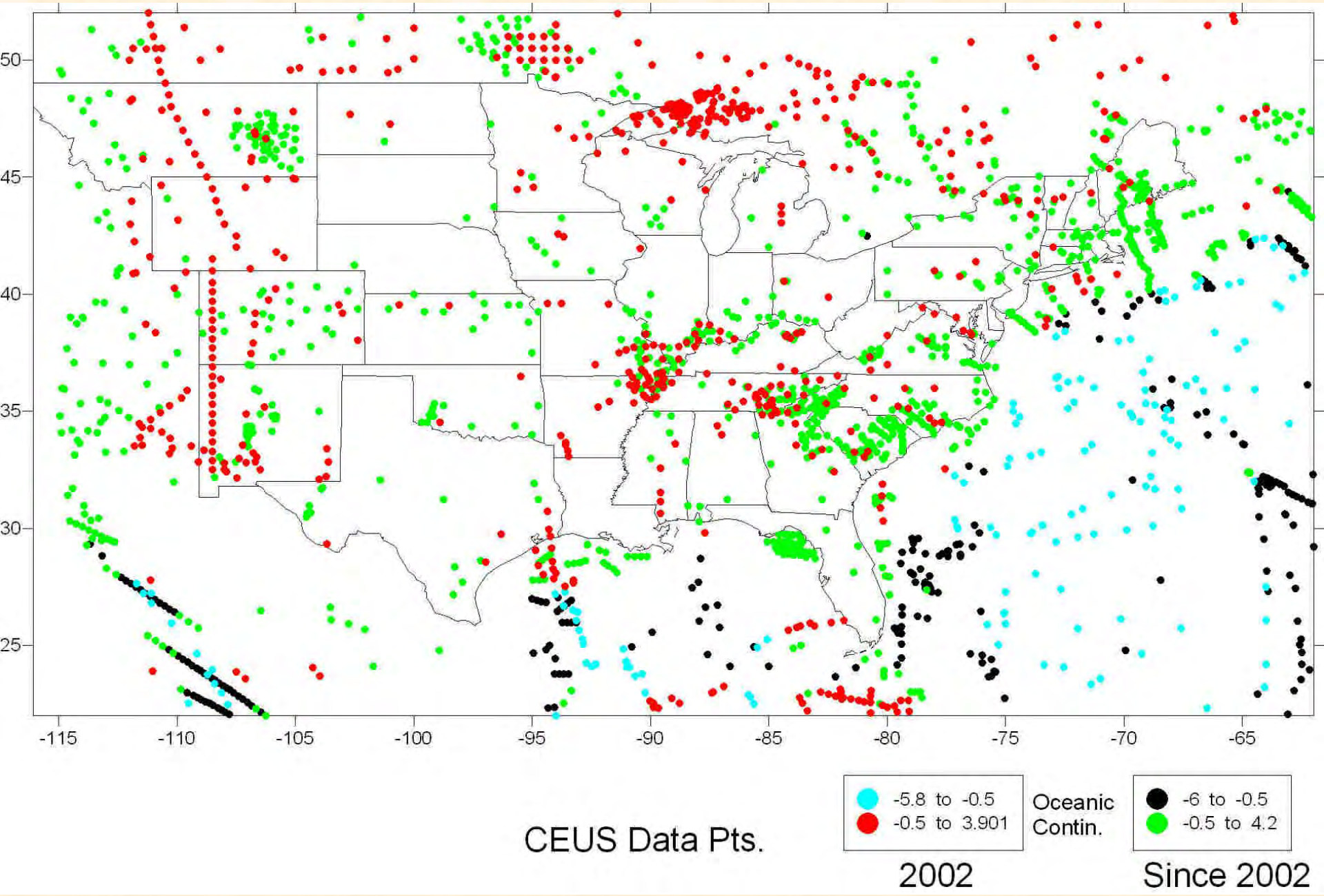
CEUS 2012 Moho Depth (km).

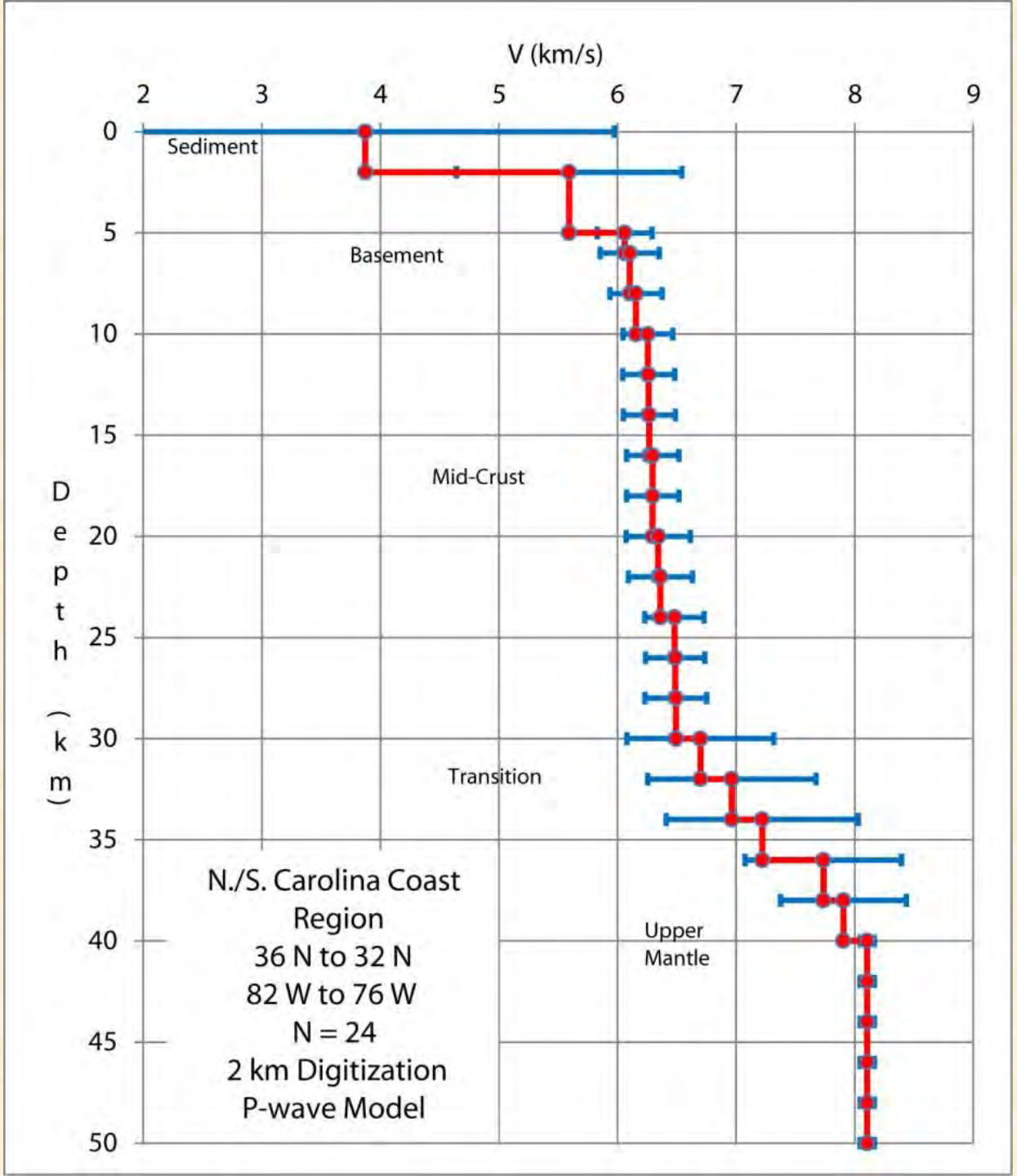
6/2/2012 (a)



CEUS 2012 Avg. Crustal Shear Vel. (km/s).

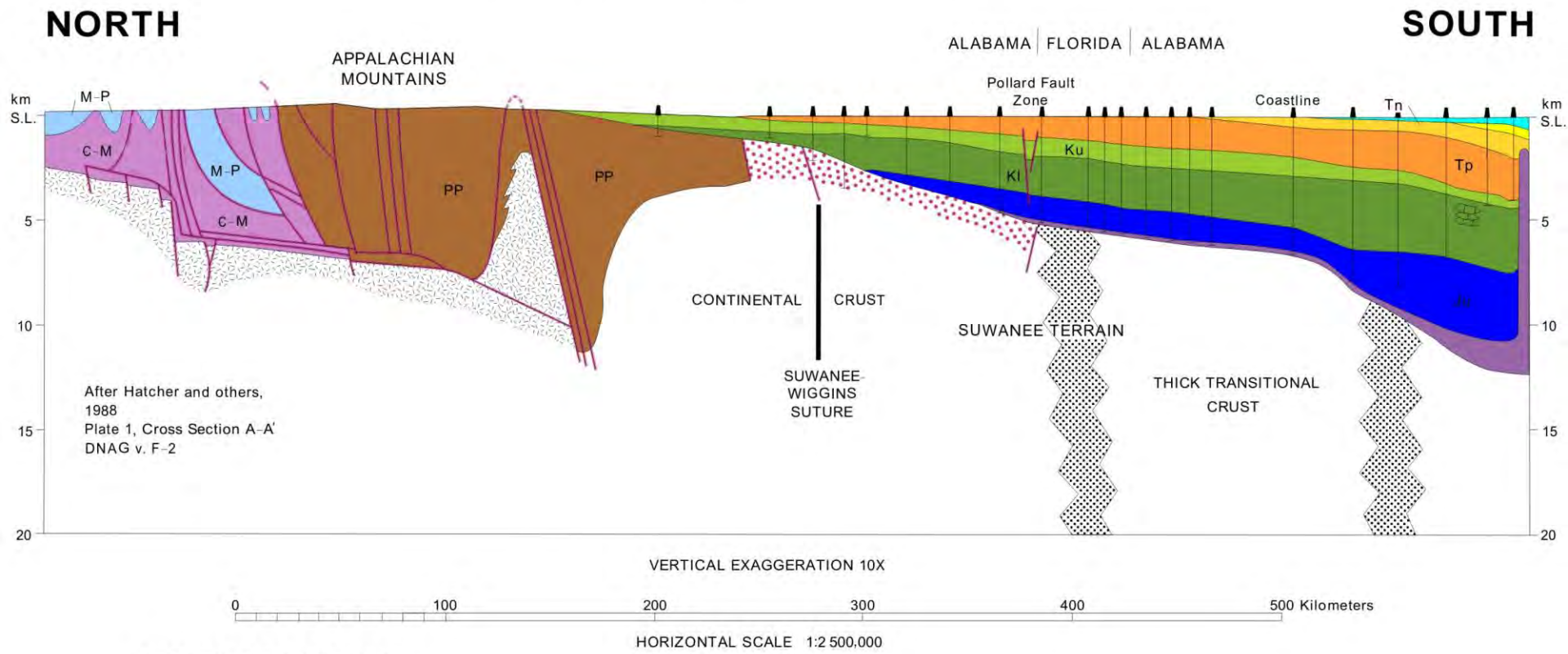
6/6/2012 (a)


50
45
40
35
30
25
-115
-110
-105
-100
-95
-90
-85
-80
-75
-70
-65
-5.8 to -0.5
-0.5 to 3.901
Oceanic
Contin.
-6 to -0.5
-0.5 to 4.2
CEUS Data Pts.
2002
Since 2002


V (km/s)
2
3
4
5
6
7
8
9
0
5
10
15
20
25
30
35
40
45
50
Depth (km)
Sediment
Basement
Mid-Crust
Transition
Upper Mantle
N./S. Carolina Coast
Region
36 N to 32 N
82 W to 76 W
N = 24
2 km Digitization
P-wave Model

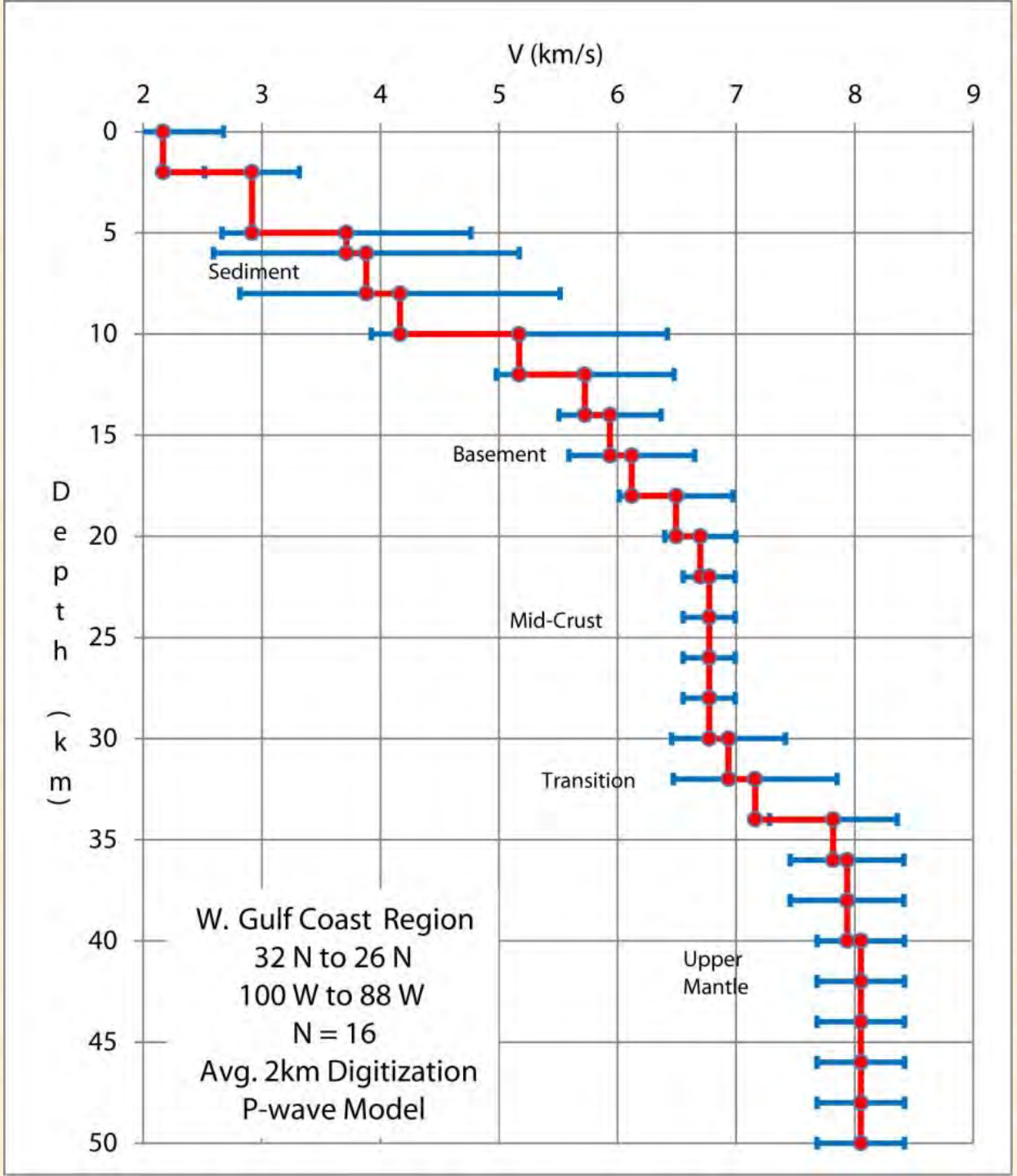
The Gulf Coast Province

ALABAMA CROSS SECTION



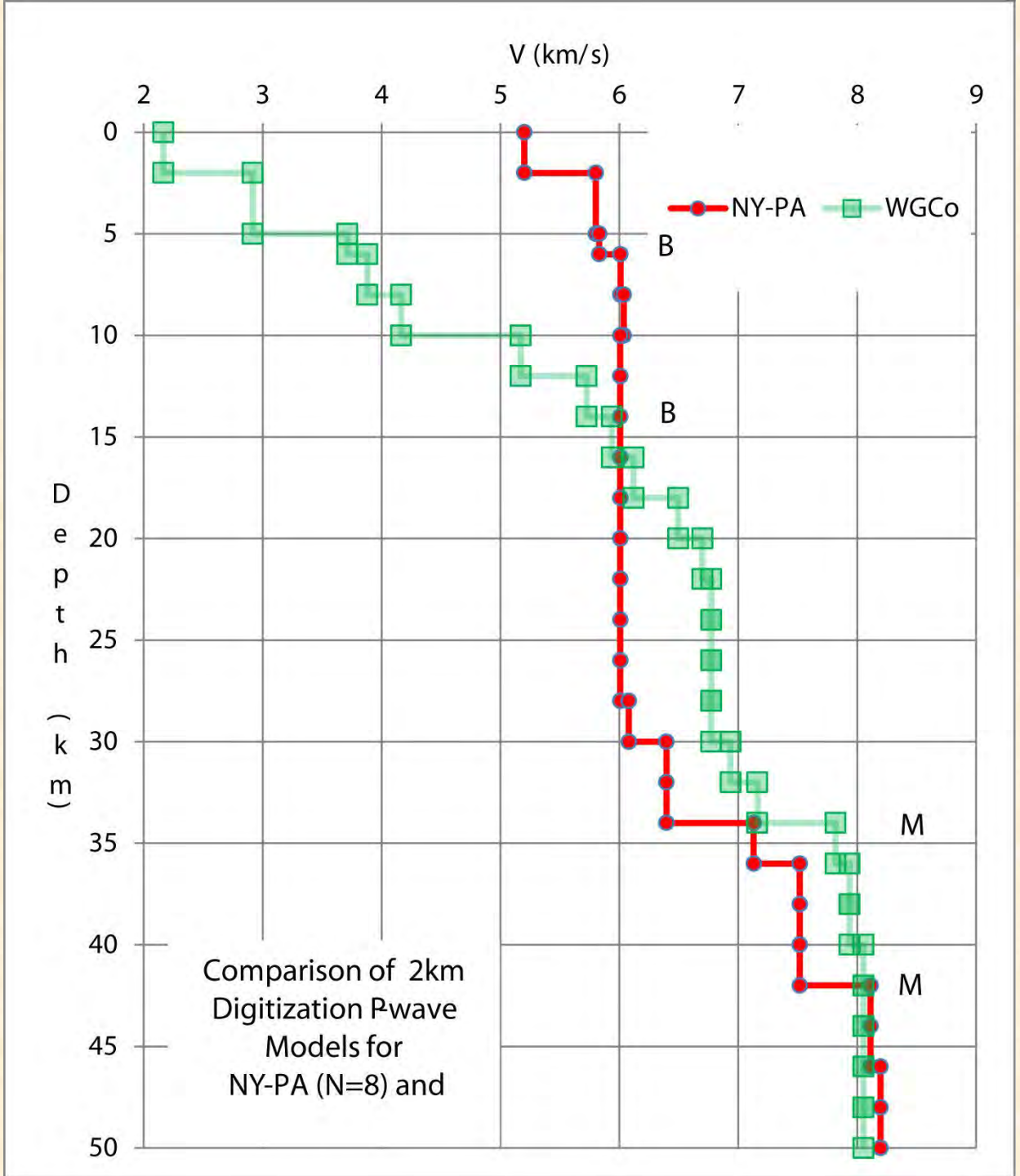
EXPLANATION

- Q — Quaternary
- Tn — Tertiary–Neogene (Mio = Miocene; Plio = Pliocene)
- Tp — Tertiary–Paleogene (Pal = Paleocene; Eoc = Eocene; Olig = Oligocene)
- Ku — Upper Cretaceous
- Kl — Lower Cretaceous
- Ju — Upper Jurassic
- Js — Middle Jurassic salt
- Permian Triassic intrusive granitic rocks
- P — Permian
- M-P — Upper Mississippian–Pennsylvanian (Platform)
- M-P — Upper Mississippian–Pennsylvanian (Flysch)
- C-M — Cambrian–Lower Mississippian (Platform)
- C-M — Cambrian–Lower Mississippian (Off shelf)
- PP — Upper Proterozoic–Lower Paleozoic metamorphic rocks

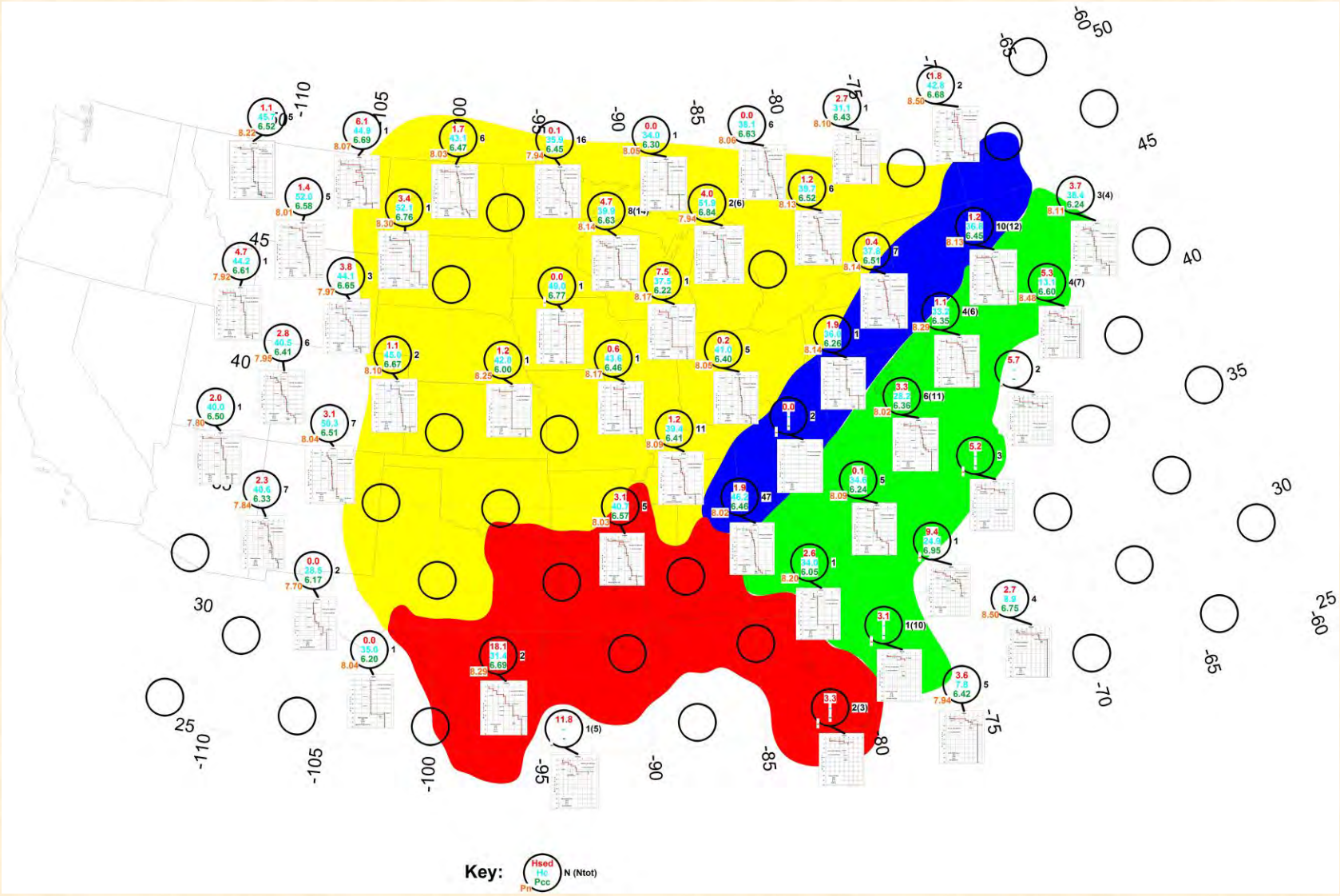

V (km/s)
2
3
4
5
6
7
8
9
0
5
10
15
20
25
30
35
40
45
50
Depth (km)
Sediment
Basement
Mid-Crust
Transition
Upper Mantle
W. Gulf Coast Region
32 N to 26 N
100 W to 88 W
N = 16
Avg. 2km Digitization
P-wave Model

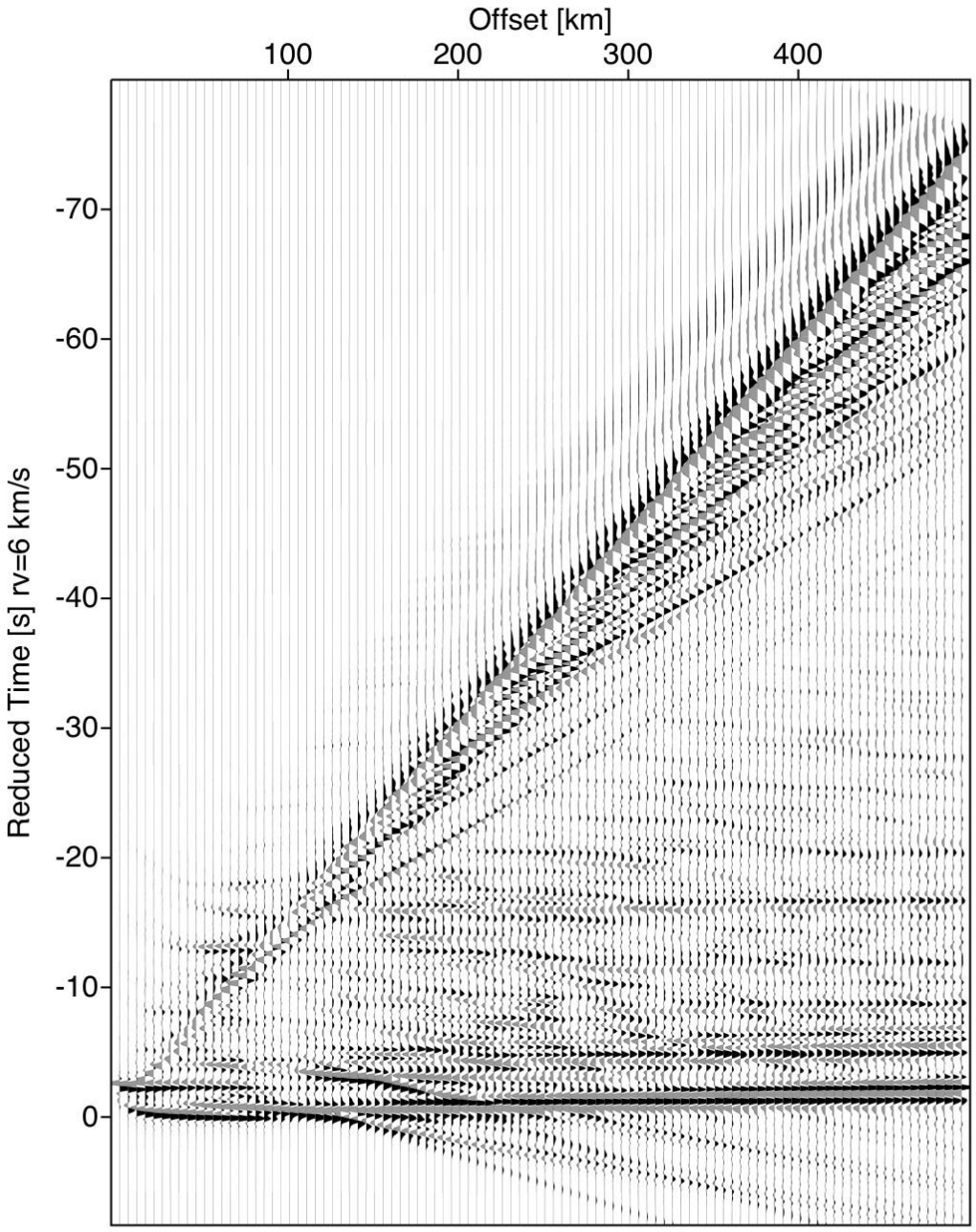
Regional Comparisons

- The Gulf Coast versus other regions

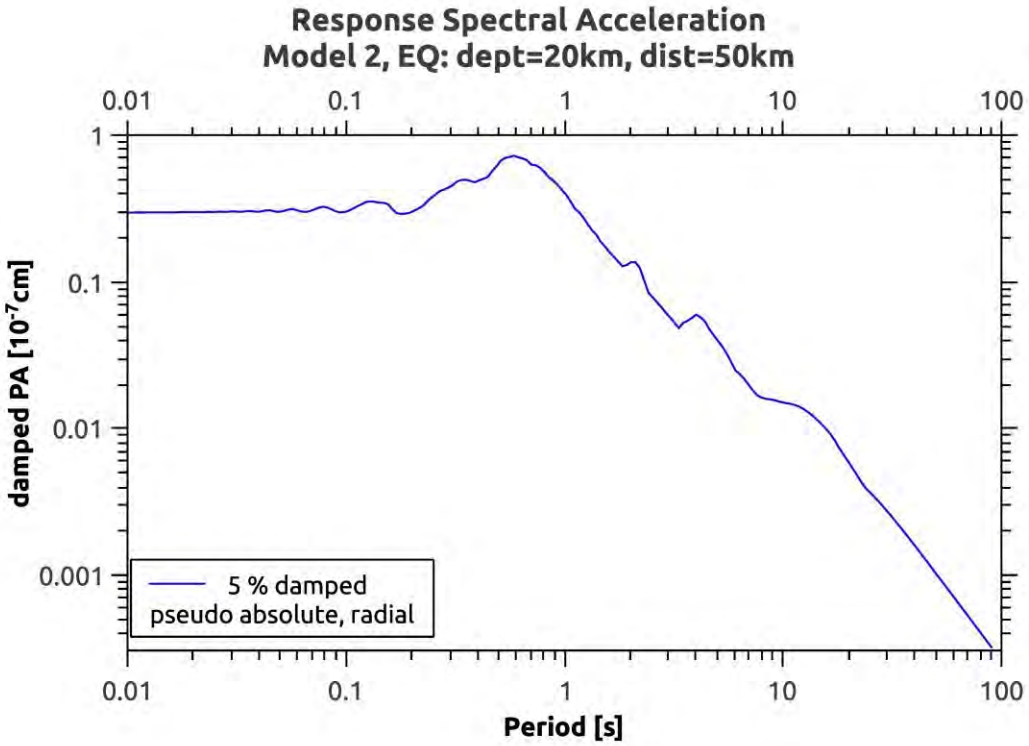

V (km/s)
2
3
4
5
6
7
8
9
0
5
10
15
20
25
30
35
40
45
50
Depth (km)
NY-PA
WGCo
B
B
M
M
Comparison of 2km Digitization P-wave Models for NY-PA (N=8) and

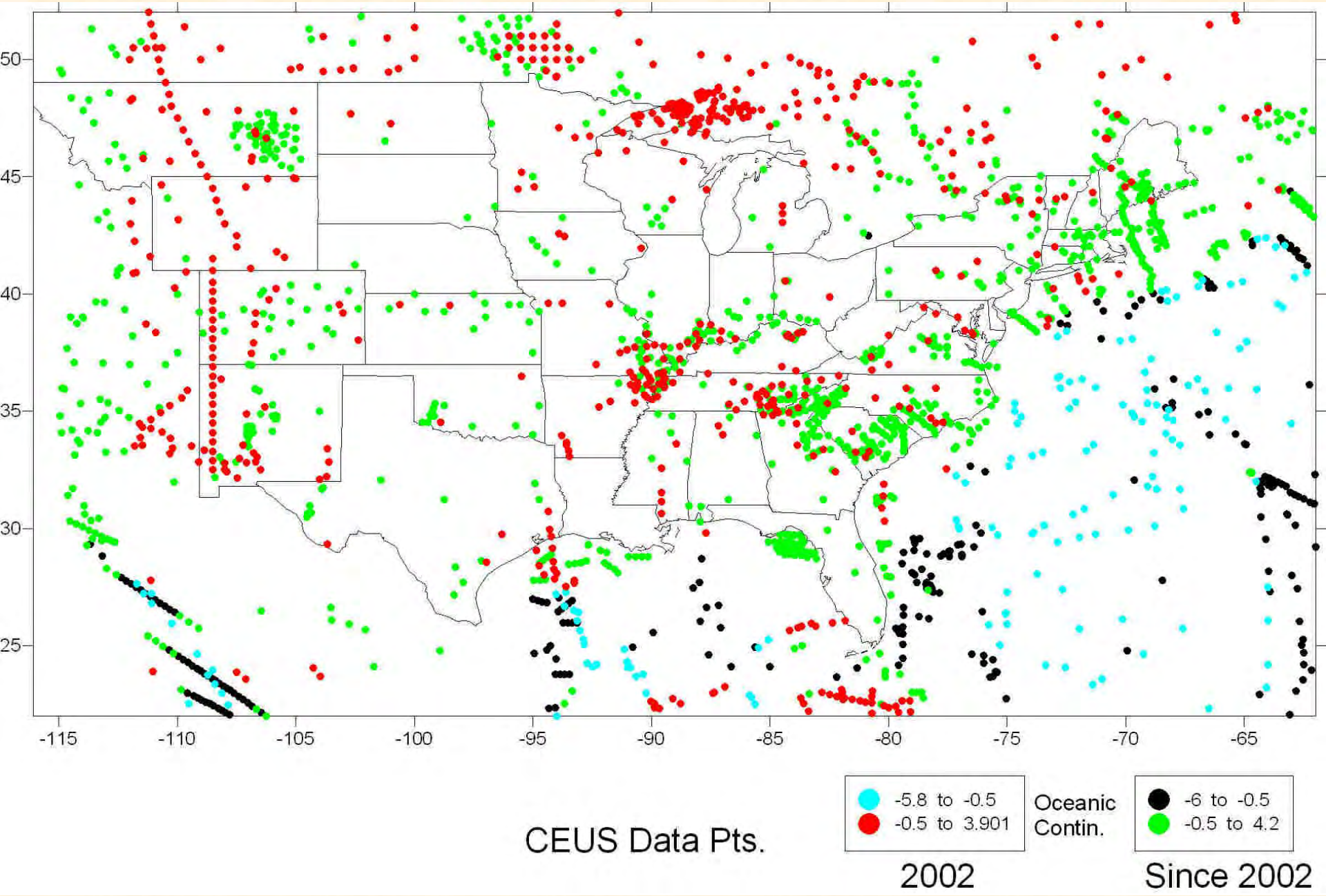
Regional Models at 3 degrees





Synthetic Seismogram: Model.3-r


Response Spectral Acceleration
Model 2, EQ: dept=20km, dist=50km
damped PA [10^-7 cm]
Period [s]
0.01
0.1
1
10
100
0.001
5 % damped
pseudo absolute, radial


50
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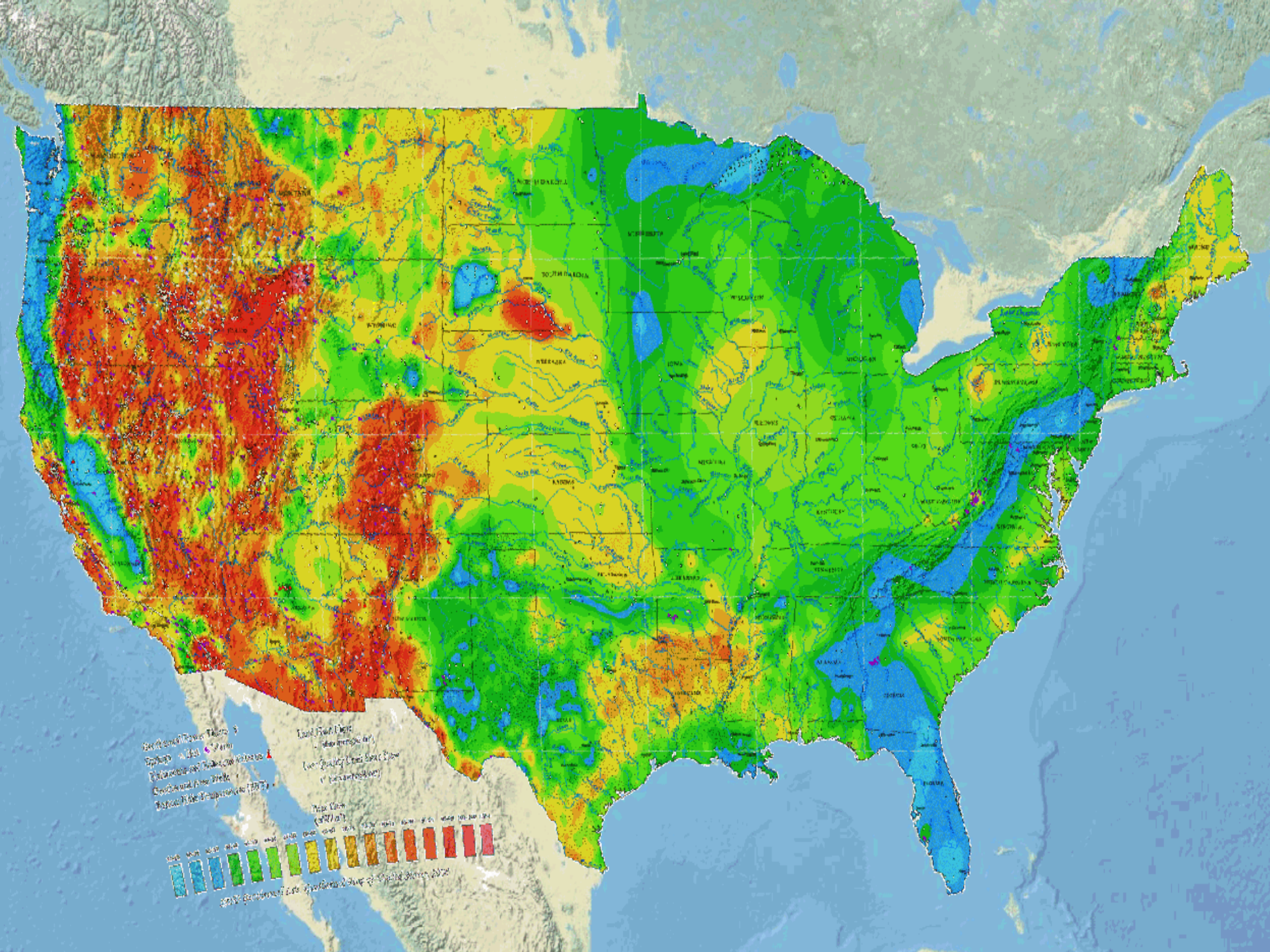
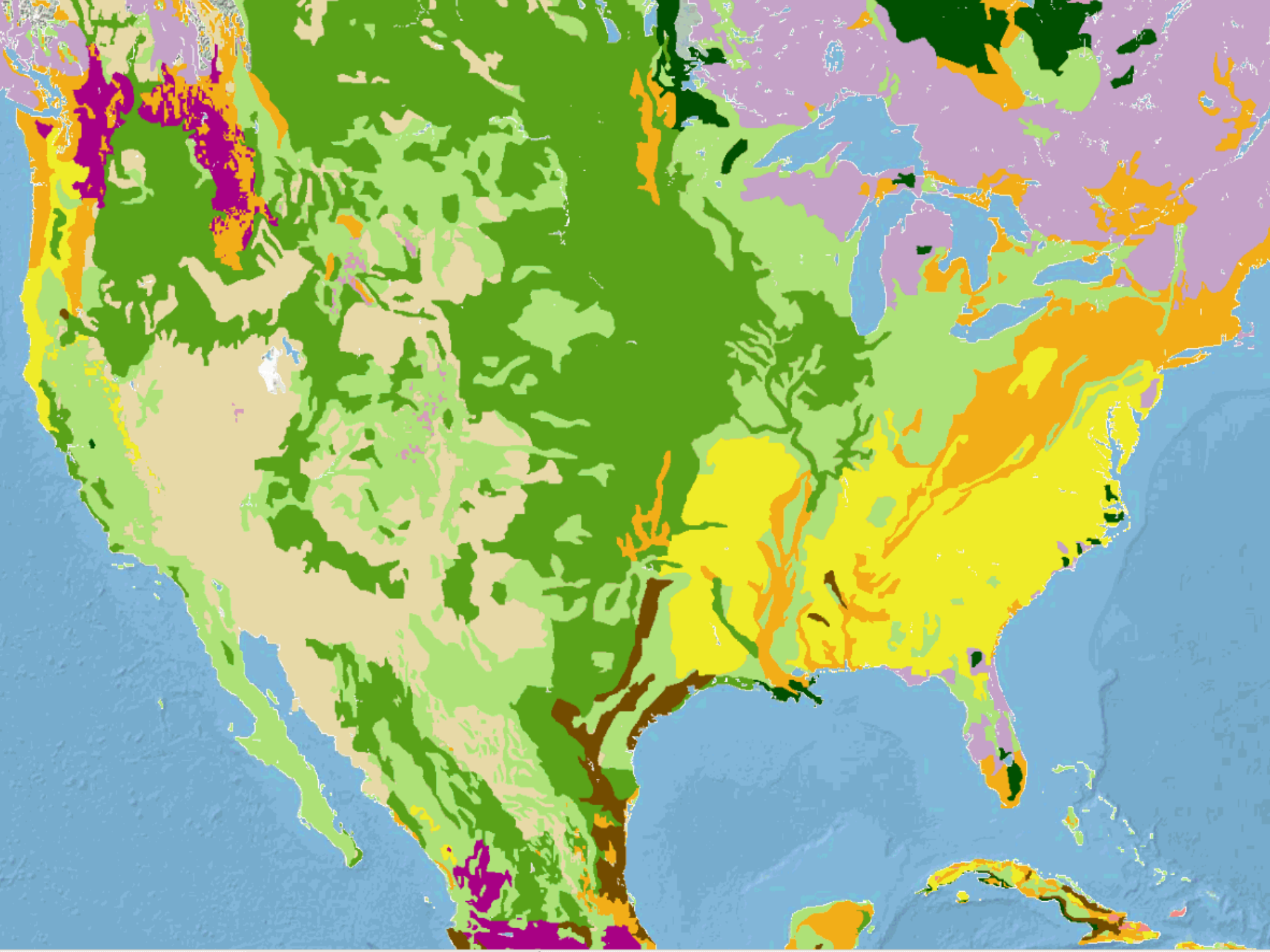
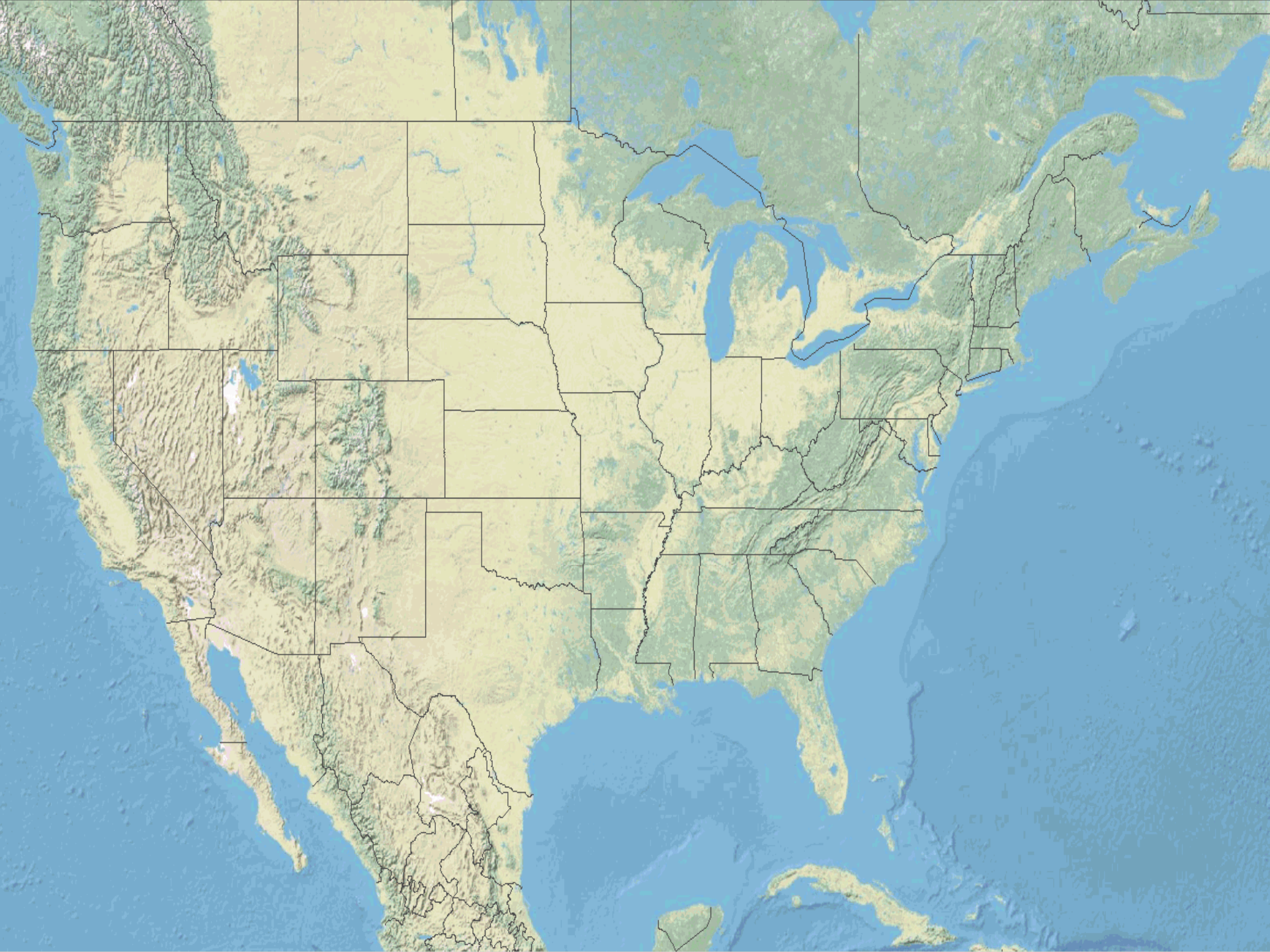
40
35
30
25
-115
-110
-105
-100
-95
-90
-85
-80
-75
-70
-65
-5.8 to -0.5
-0.5 to 3.901
Oceanic
Contin.
-6 to -0.5
-0.5 to 4.2
CEUS Data Pts.
2002
Since 2002

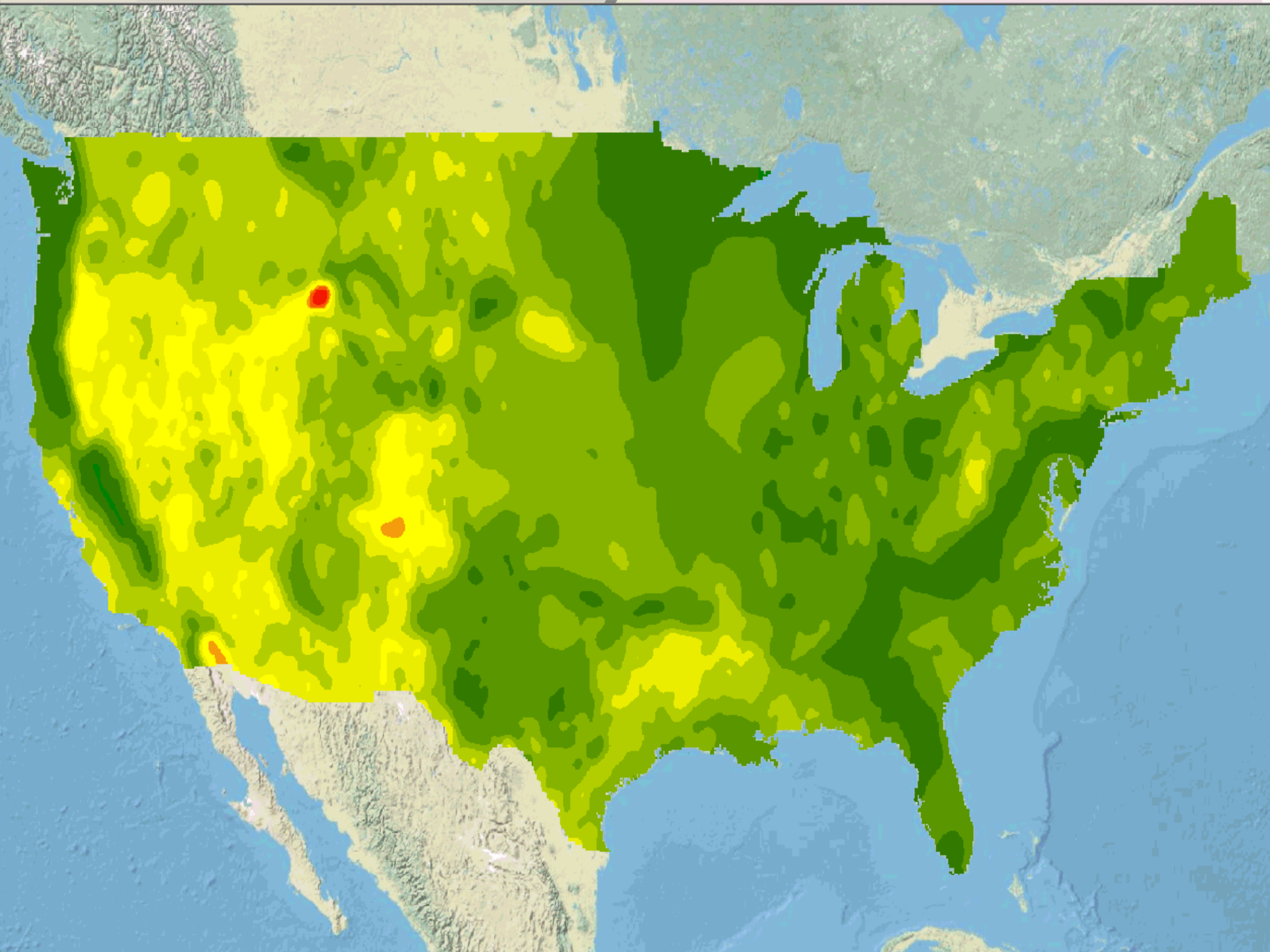
Why is this man smiling?

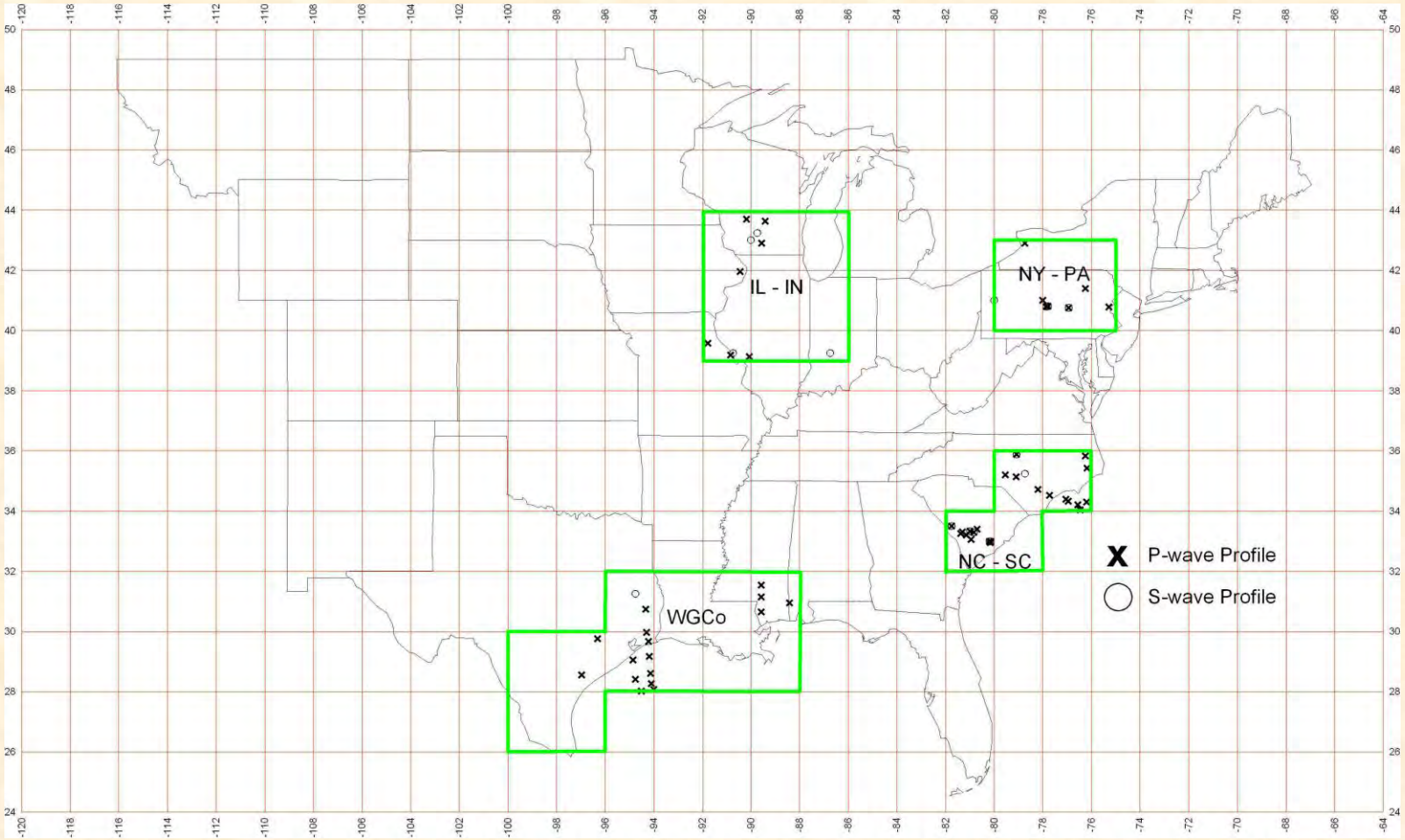

Oct. 16, 2012
We're on a roll!










IL - IN
NY - PA
NC - SC
WGCo
P-wave Profile
S-wave Profile